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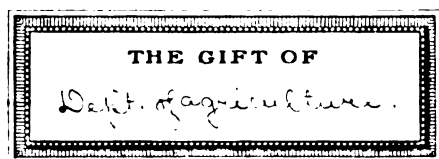
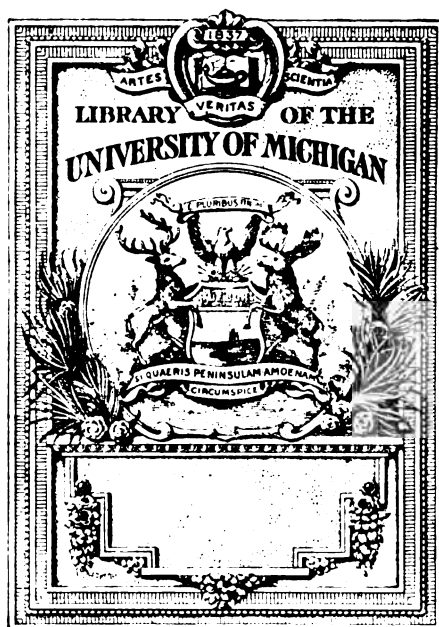
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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,

B. T. GALLOWAY, *Chief of Bureau.*

BULLETINS
OF THE
BUREAU OF PLANT INDUSTRY.

NOS. 248 TO 254.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1913.

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BUREAU OF PLANT INDUSTRY.

Chief of Bureau, BEVERLY T. GALLOWAY.

Assistant Chief of Bureau, WILLIAM A. TAYLOR.

Editor, J. E. ROCKWELL.

Chief Clerk, JAMES E. JONES.

TITLES OF BULLETINS NOS. 248 TO 254 OF THE BUREAU OF PLANT INDUSTRY.

Issued from April 30, 1912, to February 27, 1913.¹

BULLETIN No. 248.—Seeds and Plants Imported during the Period from July 1 to September 30, 1911: Inventory No. 28, Nos. 31371 to 31938. Issued September 10, 1912.

BULLETIN No. 249.—The Branching Habits of Egyptian Cotton. By Argyle McLachlan. Issued September 20, 1912.

BULLETIN No. 250.—The Diseases of Ginseng and Their Control. By H. H. Whetzel and J. Rosenbaum. Issued April 30, 1912.

BULLETIN No. 251.—The Pecan. By C. A. Reed. Issued July 12, 1912.

BULLETIN No. 252.—Studies of Fungous Parasites Belonging to the Genus *Glomerella*. By C. L. Shear and Anna K. Wood. Issued January 25, 1913.

BULLETIN No. 253.—The Kaoliangs: A New Group of Grain Sorghums. By Carleton R. Ball. Issued January 11, 1913.

BULLETIN No. 254.—The Persian Walnut Industry of the United States. By E. R. Lake. Issued February 27, 1913.

¹ Bulletins Nos. 242 to 247, 255 to 268, 271, and 272 were also issued during this period.



U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 248.

B. T. GALLOWAY, *Chief of Bureau.*

SEEDS AND PLANTS IMPORTED

DURING THE PERIOD FROM JULY 1
TO SEPTEMBER 30, 1911:

INVENTORY No. 28; Nos. 31371 to 31938.

ISSUED SEPTEMBER 10, 1912.



WASHINGTON:
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1912.

BUREAU OF PLANT INDUSTRY.

Chief of Bureau, BEVERLY T. GALLOWAY.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., March 16, 1912.

SIR: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 248 of the series of this Bureau the accompanying manuscript, entitled "Seeds and Plants Imported during the Period from July 1 to September 30, 1911: Inventory No. 28; Nos. 31371 to 31938."

This manuscript has been submitted by the Agricultural Explorer in Charge of Foreign Seed and Plant Introduction with a view to publication.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

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SEEDS AND PLANTS IMPORTED DURING THE PERIOD FROM JULY 1 TO SEPTEMBER 30, 1911: INVENTORY NO. 28; NOS. 31371 TO 31938.

INTRODUCTORY STATEMENT.

This twenty-eighth inventory of seeds and plants imported contains 20 per cent more material than the inventory covering the same period of last year and includes 668 introductions.

It contains some interesting plants collected by Mr. Frank N. Meyer in Chinese Turkestan during the winter of 1910 and the spring of 1911. These months were spent by Mr. Meyer in exploring the oases of Chinese Turkestan south of the Tien Shan Range and in crossing over this range to Chugutchak, Mongolia. Of the dangers of travel in this country Mr. Meyer himself will probably be given an opportunity to tell in a later publication. Certainly they were great enough to make the material secured of very unusual value.

Part of the collections made by Mr. C. V. Piper during his study of the forage-crop situation in the Philippines is also included. His collections from the Dutch East Indies and British India, where he traveled as an agricultural explorer, will be described in future inventories.

Experimenters living in the Northern States will probably be interested in the collection of winter wheats which Mr. Meyer secured in Chinese Turkestan (Nos. 31780 to 31791); in four varieties of hull-less barley from which the natives of Chinese Turkestan make bread (Nos. 31793 to 31796); in alfalfa varieties from Khotan, Kashgar, and Khanaka, one of which has the ability to grow in cool weather when other sorts have stopped growing (Nos. 31811 to 31815); in a variety of alfalfa from Chugutchak, Mongolia, which is said by the growers there to be much hardier than the Turkestan alfalfa, though giving only two cuttings, whereas the Turkestan gives three, but while one-third of the plants of the Turkestan alfalfa were winterkilled none of the Mongolian variety was injured (No. 31687); in a hardy wild apple found by Mr. Meyer at Kulja, Chinese Turkestan, which may prove of value for breeding purposes (No.

31688); in the oleasters from this same region, which are among the hardiest and generally most useful trees known for dry, cold countries (No. 31822); in some winter radishes for midsummer planting (No. 31697); and in four Mongolian wild roses with characters which may make them valuable for breeding purposes (Nos. 31692 to 31695).

Experimenters in the Gulf States will be interested to learn of the introduction from the Hawaiian Islands of a species of cotton entirely new to this country (No. 31680). This is a good-sized tree with large scarlet flowers, and seeds with a remarkable short brown lint on them. Only a few trees are in existence and these will be carefully guarded to prevent this very striking relative of our cotton plant from becoming extinct and forever precluding the possibility of hybrids being made between it and the cultivated species.

The attention of the same experimenters in the South is called to a collection of grasses made by the New Zealand Government for the purpose of regressing the denuded areas of South Island (Nos. 31489 to 31509); to a collection of apple varieties resistant in the mild climate of New Zealand to the woolly aphis (Nos. 31511 to 31536); to a new chance seedling plum of the Satsuma type (No. 31652) and a new variety of subtropical apple from Natal (No. 31653); to seven distinct varieties of the New Zealand flax which are reported to be superior fiber producers (Nos. 31884 to 31890); to six varieties of the sweet potato which have been either developed by the Maoris of New Zealand or brought, according to their tradition, from the Hawaiian Islands by their ancestors (Nos. 31908 to 31913); and to nine varieties of rice from Chinese Turkestan (Nos. 31823 to 31832), one of which is said to ripen its grain 10 weeks after sowing.

To those whose experimental gardens lie south of the zone of severe freezes some of the following introductions may appeal, for, although many of them are reported to be strictly tropical, their ability to grow farther north than the latitude in which they were discovered remains to be determined.

The success of the Carissa as a hedge and fruit plant has made it seem advisable to get other species of the same genus from Natal (Nos. 31840 and 31841). The awakening of subtropical horticulturists to the value of the avocado has led to the introduction of the best varieties of "paltas" from Quillota, Chile (No. 31631), and five different forms from various localities in Costa Rica and Guatemala (Nos. 31375, 31376, 31478, 31614, and 31616), while the introduction of the new species *Persea pittieri* (No. 31928) should interest particularly those who have begun to improve this new fruit plant by breeding and selection.

Since the days of Capt. Cook the seedless breadfruits of Tahiti have been famous, but the culture of these seedless forms, which are

baked and eaten as a vegetable, seems not to have spread very widely through the Tropics. The introduction of cuttings (No. 31378) may therefore stimulate an interest in this tree, which has so much of tropical romance connected with it.

Ten varieties of tropical yams (*Dioscorea* spp., Nos. 31914 to 31923) from Port Moresby, New Guinea, may add some valuable strains to the collections of West Indian forms; two interesting mangos from Tahiti (Nos. 31379 and 31380) are added to the hundred or so varieties which compose the Florida collections.

Mr. Piper calls attention to the uses of the Nipa palm as a plant for trial in the brackish swamps of southern Florida (No. 31556) and reports on the quality of the fruit of the wampee from Canton, China (No. 31730), which, while it is one of the commonest fruits of South China, is little known in Florida or Porto Rico. The cajuput tree of New South Wales (No. 31736) has made a remarkable growth on the shores of Florida and promises to be a most valuable tree for that region, and the further introduction of seed will be of interest to those who are studying the forest problems of that State.

The lacquer tree of China and Japan is a relative of our poison ivy and is quite as poisonous to some people, but the remarkable character of the sap, which is different from the paint oils or varnishes in use in this country, makes its culture worthy of the consideration of chemists. The drying process is not a simple oxidation phenomenon, but it depends on the action of enzymes upon albuminoids in the presence of an organic acid, and, as the product, lacquer, is one of the most durable and perfect wood coatings known, it would seem worth while to find ways by which it can be handled by painters. The introduction of the crude lacquer and seeds of the lacquer tree (No. 31639) are for the purpose of interesting the paint and varnish makers of this country.

The extensive employment in India of the juice of a certain tropical persimmon, when mixed with charcoal, as a coating for the planks of boats has made it seem worth while to add this species to our collection of Diospyros (No. 31488).

To those who wish to test new forms in their gardens, the narras from Walfisch Bay, a dune-forming, thorny cucurbitaceous plant (No. 31401) which produces fruits upon which the Hottentots live and thick nutlike seeds which are used in South Africa as a substitute for almonds, will perhaps be of interest; or one of Mr. Piper's introductions from the Philippines, a vine with beautiful globose smooth red fruits as large as an orange (No. 31588); or the pacuri of Paraguay, a plant as frost resistant as the orange, which bears edible fruit (No. 31872).

As heretofore, the manuscript for this inventory has been prepared by Miss Mary A. Austin, and the botanical determinations have been made and the notes on geographic distribution arranged by Mr. H. C. Skeels, under the supervision of Mr. Frederick V. Coville, of the Office of Taxonomic and Range Investigations. The general supervision of this inventory, as of all the publications of this office, has been in the hands of Mr. Stephen C. Stuntz.

DAVID FAIRCHILD,
Agricultural Explorer in Charge.

OFFICE OF FOREIGN SEED AND PLANT INTRODUCTION,
Washington, D. C., February 19, 1912.

INVENTORY.

31371. XANTHOSOMA sp.

Yautia.

From Monte Cristi, Dominican Republic. Procured by Mr. Frederick L. Lewton, of the Bureau of Plant Industry. Received July 1, 1911.

"These tubers were obtained by Mr. Lewton on the market under the name of yautia. They are oblong in form, one specimen being 6 inches in length and $2\frac{1}{4}$ inches in greatest diameter, with a weight of 10 ounces. The sprouts are pink or reddish. The flesh is white and nonacid; when cooked it becomes slightly purplish and is moderately firm. The flavor is rather inferior." (R. A. Young.)

31372. XANTHOSOMA sp.

Yautia.

From Port au Prince, Haiti. Procured by Mr. Frederick L. Lewton, of the Bureau of Plant Industry. Received July 1, 1911.

"The tubers of this variety were obtained on the market under the name of *Malanga* by Mr. Lewton. They are roundish in general form, some specimens being about $2\frac{1}{2}$ by 3 inches in size and weighing 5 to 6 ounces. The sprouts are reddish in color. The flesh is acrid when raw, but the acidity is destroyed by boiling for 35 or 40 minutes. The flesh is very firm when cooked and is of fair flavor." (R. A. Young.)

31373. IPOMOEA BATATAS L.

Sweet potato.

From Broadwood, New Zealand. Presented by Mr. George Harris, at the request of Mr. T. W. Adams. Received at the Plant Introduction Garden, Chico, Cal., June 28, 1911.

"Kumaras."

31374. INOCARPUS EDULIS Forst.

Tahiti-chestnut.

From Tahiti, Society Islands. Procured by Mr. North Winship, American consul. Received July 1, 1911.

"O Tahiti-chestnuts come from what is considered the best tree on this island. The nut should be planted about 4 or 5 inches deep, good loamy soil preferred, in the place where the tree is desired. It is of slow growth, but makes a beautiful tree, growing to great size and yielding abundantly. Keep the seed and the young plant damp, but not wet." (Winship.)

"These seeds are much prized by the natives as food, being eaten boiled or roasted. They are said to be less palatable than the chestnut." (Fairchild.)

31375 and 31376. PERSEA AMERICANA Miller.

Avocado.

From San Jose, Costa Rica. Presented by Mr. Carlos Wercklé. Received July 3, 1911.

Seeds of the following:

31375. "Broad oval."

31376. "Long, but without neck or stem."

"These are seeds of large, very thick-fleshed and very good varieties. They are about the best that come to the market. Plain green." (Wercklé.)

31377. ENTELEA ARBORESCENS R. Br.**Whau.**

From Tauranga, New Zealand. Presented by the Tauranga Fruit-Testing Station, Department of Agriculture, New Zealand. Received July 3, 1911.

See No. 30833 for description.

31378. ARTOCARPUS COMMUNIS Forst.**Breadfruit.**

From Tahiti, Society Islands. Presented by Mr. North Winship, American consul. Received at the Plant Introduction Garden, Chico, Cal., June 22, 1911. Forwarded to Washington, D. C., and received June 27, 1911. Numbered July 6, 1911.

"These cuttings should be planted in loamy soil, the top of the stalk being closed to prevent insects from entering, and the plant should be protected from the midday sun until it shows signs of life. This is a very fine variety of the Tahiti breadfruit, being about the size of a grapefruit and without seed." (*Winship*.)

31379 and 31380. MANGIFERA INDICA L.**Mango.**

From Tahiti, Society Islands. Procured by Mr. North Winship, American consul. Received at the Plant Introduction Garden, Chico, Cal., June 22, 1911. Numbered July 6, 1911.

Plants of the following; quoted notes by Mr. Winship:

31379. "*Superba* Hook. This gives a fine large fruit, heavy and almost round; its color is yellowish golden."

31380. "*Altissima* Blanco. This is practically the same as the preceding, possibly longer and more pointed at the bottom; its color is pink or red, sometimes with a violet hue."

"Both of these fruits are less fibrous than the other mangos found here, and are very luscious. These trees begin to bear with the commencement of the rainy season. It is thought that both of these varieties came originally from India."

These two were sent in as *Mangifera superba* and *M. altissima*, respectively, though they are now considered merely as forms of *M. indica*.

31381. PERSEA AMERICANA Miller.**Avocado.**

Secured on the market at Laredo, Tex., by Dr. David Griffiths, of the Bureau of Plant Industry, June, 1911. Received July 5, 1911.

"A Mexican avocado, the only one of the kind found. Brownish black in color. The outer skin hard, rather brittle, and easily peeled off from the edible flesh. Flavor good, flesh firm." (*Griffiths*.)

31383. ROLLINIA sp.

From Piracicaba, Brazil. Presented by Mr. Clinton D. Smith, Fazenda Modelo do Estado de São Paulo. Received July 7, 1911.

"Variety *Cabeça de Negro*. The natives call this fruit *araticu*." (*Smith*.)

31384 to 31388.

From the vicinity of Chungking, China. Presented by Mr. Albert W. Pontius, American consul. Received June 27, 1911.

Seeds of the following; quoted notes by Mr. Pontius:

31384. HORDEUM VULGARE L.

Barley.

Bearded.

31385. HORDEUM VULGARE var.

Barley.

"Black. Considered superior. Not raised extensively."

31384 to 31388—Continued.**31386. HORDEUM VULGARE** var.**Barley.**

Beardless.

"All three of these varieties are planted in the beginning of November, the crop ripening in early May following. They are chiefly used in the manufacture of wine spirits, very little being used as human or animal food."

31387. BRASSICA NAPUS L.**Rape.**

"Black. This variety grows to a height of about 3 feet and ripens in April or May. The oil obtained from the seed is dark in color."

31388. BRASSICA JUNCEA (L.) Cass.

"Yellow. This variety grows to a height of about 5 feet and ripens in April or May. The oil extracted from the seed is of a light color."

31389 and 31390. FELJOA SELLOWIANA Berg.

From California. Presented by Mr. H. Hehre, Los Angeles, Cal., who procured them from the garden of Mrs. Ingraham. Received November, 1910. Numbered for convenience in recording distribution July 10, 1911.

Plants grown from seed received on the foregoing date:

31389. "Variety *Hehrei*. This large, long fruit was originated by me years ago by selection and crossbreeding. It gets to be 3 inches in length by 2 inches in diameter, has smooth skin, and is of good flavor." (*Hehre*.)

31390. A short, round variety.

See Nos. 26120 and 26121 for general notes on this fruit.

31391. PINUS ELDARICA Medw.**Pine.**

From Tiflis, Caucasus, Russia. Presented by Mr. A. Rolloff, director, Botanic Garden. Received July 10, 1911.

Distribution.—On the rocky slopes of the valleys of the streams in the dry, central region of the Trans-Caucasian provinces of southeastern Russia.

31392. ANACARDIUM OCCIDENTALE L.**Cashew.**

From Maulmain, Lower Burma, India. Procured from the Deputy Commissioner at Maulmain, by Mr. M. K. Moorhead, American consul, Rangoon, Burma, at the request of the consul general at Calcutta. Received July 10, 1911.

"Cashew nuts are the kidney-shaped nuts of the *Anacardium occidentale*, known in Burmese as *Thio-thayet-si* (seeds of the *Thio-thayet*, 'Ceylon mango'). The tree, of which there is only one variety in Burma, was originally introduced from Brazil, where it is known as *Acaju* (hence the Portuguese *Cajew* and the English *Cashew*). It is planted commonly on roadsides and in fruit gardens in Maulmain, Amherst district, and in Tavoy and Mergui districts. It has run wild in the sandy coast forests of western India, chiefly on the borders of the backwaters of Travancore. It is propagated in India and Burma by sowing the nuts and not yet by grafting or other methods, though these admit of being applied to it." (*Mr. J. Mackenna, Director of Agriculture, Burma.*)

31393. CEIBA PENTANDRA (L.) Gaertner.**Kapok.**

From Buitenzorg, Java. Presented by the Director of Agriculture. Received July 11, 1911.

"A high tree, 20 to 30 meters [65 to 100 ft.], with spreading horizontal branches. The cotton covering the seeds is used in making beds and pillows. The wood is white and soft, but in Porto Rico is considered desirable for minor building purposes, such

as inside partitions. The leaves are palmately divided, like those of the horse-chestnut, and it is sometimes called the 'five leaves silk cotton' to distinguish it from *Ochroma* and others which produce a silky fiber. The trunks of young trees of this species are beset with large, conical spines, but in age these fall away and are to be found only on the branches. The trunk is further transformed by the growth of prominent wings or buttresses, sometimes 2 feet (0.6 meter) wide, while but a few inches thick. In west Africa, where this tree is larger and more luxuriant, pieces of these supporting wings are sawed out and used as doors of native houses. The fiber surrounding the seeds of this and related species is the 'Kapk' of commerce, and is exported in considerable quantities from the west coast of Africa." (*Cook and Collins. Economic Plants of Porto Rico, 1903, p. 111.*)

"'Kapk' has come into use very largely in certain European countries in recent years, notably in Germany and Holland, as a material for stuffing cushions, pillows, chairs, bedding, and similar articles. For such purposes its nonhygroscopic character and its softness and resiliency render it peculiarly suitable. It is also stated to be less absorbent and less liable to harbor insect parasites than the materials generally employed in upholstery, and, according to the authorities of the Pasteur Institute in Paris, it can be sterilized by heat at least three times without being seriously damaged, whereas feathers and other upholstery materials do not usually survive this treatment more than twice." (*Indian Vegetable Flosses or "Silk Cottons." Bulletin of the Imperial Institute, vol. 3, 1905, p. 223.*)

Distribution.—A tall tree found in the forests throughout the warmer parts of India and Ceylon; also in tropical Africa, the West Indies, and South America.

31394. *CRYPTOMERIA JAPONICA* (L. f.) D. Don.

From Yokohama, Japan. Purchased from the Yokohama Nursery Co. Received July 8, 1911.

See No. 2922 for description.

31395 and 31396.

From Foochow, China. Presented by Mr. T. M. Wilkinson. Received July 5, 1911.

Seeds of the following; quoted notes by Mr. Wilkinson:

31395. *MEDICAGO LUPULINA* L.

Black medick.

"A clover with low-growing stems, inclined to lie along the ground and take root at joints. Starts in new places like white clover. Leaf about the size of white clover. Blossom yellow; seed grows on stem something like alfalfa instead of in head like red or white clover. It may be well to experiment with it carefully, for if it is not found to be of value as a forage or pasture plant it may prove to be as much of a pest as the sweet clover is in some of the States."

31396. *TRITICUM AESTIVUM* L.

Wheat.

"This is planted here the last of November and December; it grows during the rainy season and ripens during the humid spring season. Seems to be rust-proof and does not blight easily. Straw quite stiff and strong. May prove to be a valuable variety of winter wheat for the Southern States."

31397. *CAPSICUM* sp.

Red pepper.

From Paraguay. Presented by Mr. C. F. Mead, Villa Encarnacion. Received July 12, 1911.

"Called in Guarany *Kuti*. A very small and very strong pepper, a good rival for, if not stronger than, the tabasco pepper. Found growing wild in the mountains of Paraguay, but I know nothing of the plant or habit of its growth, as the seeds were procured for me by Indians near the yerbales of Alta Parana." (*Mead.*)

31398 to 31400. NICOTIANA TABACUM L.**Tobacco.**

From the Isthmus of Tehuantepec, Mexico. Presented by Mr. Lewis W. Haskell, American consul, Salina Cruz, Mexico. Received July 12, 1911.

Seeds of the following; quoted notes by Mr. Haskell:

31398. "I am told that this sample will show three classes:

"(1) *Criollo*, which grows 3 feet or more in height, with about 30 leaves to the flower. From 20 to 24 would be left after topping. Length of leaf 40 to 60 centimeters and a proportionate width, coming to a point. Coarse vein, dark color, and poor quality.

"(2) *Criollo*, which grows about the same size and shape as the above but of a great deal finer quality. Small vein, fine leaf, light weight. Color, colorado or colorado maduro. This is the class largely used in Valle Nacional and San Andres Tuxtla and is much esteemed for its size of leaf and its softness or fineness. It is mixed with the first mentioned to 'add weight.'

"(3) *Cubano* or *Habanero*, which grows somewhat larger than the above, but the leaves are more widely separated and there are but from 14 to 18 left at topping. Leaves almost round; color colorado claro or claro. Is of very fine texture and light weight."

31399. "This came from Acayucan and is the ordinary kind raised there. Acayucan is located on the Isthmus of Tehuantepec, and is in the State of Vera Cruz."

31400. "As to this variety, the natives hereabouts do not distinguish, so all I can say for it is that it is tobacco seed. It comes from the vicinity of Modias Aguas on the Tehuantepec National Railway, which is situated on the Gulf slope of the Isthmus. No tobacco is grown on this, the Salina Cruz side of the Isthmus."

31401. ACANTHOSICYOS HORRIDA Welw.**Narras.**

From Walvisch Bay, Africa. Presented by Mr. Richard Hörnig, Farm Sachsen, Tsumeb, German Southwest Africa. Received July 8, 1911.

"A plant belonging to the same family as the squash, which it somewhat resembles. It is an important dune former, and continues to grow with the increasing height of the dune, so that its younger shoots remain at the surface, forming a dense, thorny shrub, while the root system penetrates to a considerable depth, tapping the underground water and securing such a supply that drops exude and fall from the cut ends of assimilating stems.

"Old stems buried in the accumulating sand become as stout as one's arm and ensheathed in a thick layer of corrugated cork, obviously serving in part as water storers. The plant is unisexual and each dune apparently contains a single individual, for the two sexes are never found together.

"Flowering commences in November and by the middle of February the female plants produce ripe fruits, which are borne in great profusion, and for about four months in the year render the Hottentots independent of other sources of food and, to a large extent, of water also. The fruits are spheroidal in shape and about 9 inches in diameter. The juicy yellow flesh is much relished by the natives, who consume large quantities of it while fresh and lay by a store for winter use in the form of hard, flat cakes obtained by evaporation. Its food value is attested by their fat and sleek appearance during the narras season.

"The faculty of enjoying the juice evidently has to be acquired, for it has a sweet, sickly flavor and contains an acid principle very irritating to the tongue and palate of those unaccustomed to it; it is said that at the end of the narras season the lips of even the habitual consumers are swollen and inflamed. The seeds, which somewhat

resemble those of the squash, are very nutritious and were formerly exported to Cape Town under the name of 'butternuts,' where they found a market among the native population and were also used by Europeans as a substitute for sweet almonds." (*Pearson, Notes on a Journey from Walfish Bay to Windhuk, Kew Bulletin of Miscellaneous Information, No. 9, 1907, p. 342, figs. 1 and 2.*)

Distribution.—In the desert regions near the west coast of Africa from the vicinity of Mossamedes southward to Namaqualand.

31402. CANNA sp.

Canna.

From the forests around El Boquete, Chiriqui, Panama, at an altitude of 3,250 to 4,250 feet. Presented by Mr. H. Pittier, collector, Smithsonian Biological Survey of the Panama Canal Zone. Received July 13, 1911.

31403. NICOTIANA TABACUM L.

Tobacco.

From Jocoto, Guatemala. Presented by Mrs. Lucie Potts, Livingston, Guatemala. Received July 12, 1911.

31404. CASTANEA CRENATA Sieb. and Zucc.

Chestnut.

From Japan. Procured by Mr. Thomas Sammons, American consul general, Yokohama, Japan, who secured them through the Agricultural Experimental Farm at Aomori, Mr. H. Iwaya, of the village of Shinjomura, Higashitsuruga-Gori, near Aomori, having gathered the same by special request. Received December 27, 1910. Numbered for convenience in recording distribution July 14, 1911.

Aomori.

31405. CRYPTOCARYA RUBRA (Mol.) Skeels.

Peumo.

From the province of Valparaiso, Chile. Received through Mr. José D. Husbands, Limavida, via Molina, Chile. Received June 22, 1911.

See Nos. 23897, 24310, and 27904 to 27924 for previous introductions.

31406 to 31409. CITRUS spp.

From Buitenzorg, Java. Presented by Mr. H. Wigman, jr., assistant director, Botanical Garden. Received July 10, 1911.

Seeds of the following; native names quoted:

31406. CITRUS sp.

"*Djeroek tjina konde.*"

31407. CITRUS DECUMANA (L.) Murr.

Pomelo.

"*Djeroek delima.*"

31408. CITRUS DECUMANA (L.) Murr.

Pomelo.

"*Djeroek pandan.*"

31409. CITRUS NOBILIS Lour.

31410. CASTILLA ELASTICA Cerv.

Central American rubber.

From Tula, Vera Cruz, Mexico. Presented by Mr. A. D. Patchen. Received July 15, 1911.

Introduced in order to encourage the growing of the various rubber trees in Porto Rico, Hawaii, and the Canal Zone.

31411 to 31464. SOLANUM TUBEROSUM L.**Potato.**

From Chile. Received through Mr. José D. Husbands, Limavida, via Molina, Chile, June 22, 1911.

Tubers.

31465. MEDICAGO HISPIDA APICULATA (Willd.) Urban.

From Jeolikote, United Provinces, India. Presented by Mr. Norman Gill, superintendent, Kumaon Government Gardens, Douglas Dale, at the request of Rev. N. L. Rockey, Gonda, United Provinces. Received July 14, 1911.

31466. CHRYSANTHEMUM CINERARIAEFOLIUM (Trev.) Vis.**Chrysanthemum.**

From Erfurt, Germany. Purchased from Haage & Schmidt. Received July 10, 1911.

Introduced for the work of the Office of Drug-Plant Investigations in growing in the United States the various species of this genus which produce the pyrethrum insect powder.

31467. MEDICAGO SATIVA L.**Alfalfa.**

From Quetta, India. Secured by Mr. F. Booth Tucker, Salvation Army, Simla, India, from Mr. G. H. Frost, subconductor, Military Farm, Quetta. Received July 10, 1911.

31468. MAURITIA SETIGERA Griseb. and Wendl.**Morichy.**

From La Brea, Trinidad, British West Indies. Presented by Mr. H. Caracciolo, St. Joseph Nurseries. Received July 19, 1911.

"A handsome palm growing about the asphalt beds of La Brea. The seeds ripen in May and could readily be gathered, as the palm is abundant locally." (*Oglesby Paul.*)

See No. 31326 for distribution of this species.

31469. FICUS PSEUDO-CARICA Miquel.**Fig.**

From Eritrea, East Africa. Presented by Prof. T. Batorate, director, Colonial Agricultural Experiment Station, Asmara, through Mr. Walter T. Swingle. Received July 19, 1911.

"A native fig introduced for use in the fig-breeding work of the Office of Crop Physiology and Breeding Investigations. This species occurs commonly in a wild state in Eritrea and Abyssinia and bears small but edible fruits. We already have it in California and it promises to be important in supplying early *Blastophaga* with pollen to caprify the spring crop of figs." (*W. T. Swingle.*)

31470 to 31473.

From Honduras. Presented by Dr. R. Fritzgartner, Tegucigalpa. Received July 19, 1911.

Seeds of the following; quoted notes by Dr. Fritzgartner:

31470. CASIMIROA SAPOTA Oerst.

Matasano, or white sapote.

31471 to 31473. NICOTIANA TABACUM L.

Tobacco.

31471. "From Chimbo, 3,900 feet altitude."

31472. "From Santa Lucia, 4,800 feet altitude."

31473. "From Aurora, 5,000 feet altitude."

31474 and 31475. NICOTIANA TABACUM L.**Tobacco.**

From Cuba. Presented by Dr. E. F. Cabada, Cienfuegos. Received July 21, 1911.

Seeds of the following:

31474. "*Vuelta Abajo*." From the district immediately west of the city of Pinar del Rio, province of the same name.

31475. "*Remedios*." From the district surrounding the town of this name, province of Santa Clara.

31476. BRASSICA OLERACEA CAPITATA L.**Cabbage.**

From China. Brought in by Mr. G. Weidman Groff, of the Canton Christian College, July 22, 1911.

"*Wong nga paak*. An excellent Chinese cabbage with very long head, and when bleached like celery, of excellent flavor." (Groff.)

31477. MANGIFERA INDICA L.**Mango.**

From Piracicaba, Brazil. Presented by Mr. Clinton D. Smith, Escola Agricola Practica, Luiz de Queiroz. Received July 26, 1911.

"Grafts from our best tree. This variety is the *Espada* and is less stringy than the others, also has a larger proportion of pulp to pit." (Smith.)

31478 to 31481.

From San Jose, Costa Rica. Presented by Mr. C. Wercklé. Received July 17, 1911.

Seeds of the following:

31478. PERSEA AMERICANA Miller.**Avocado.**

"*Palta* No. 1. Fruit large (390 grams [13½ oz.]), intense green, shortly pyriform-obovate; thick meat; highest quality. Weight of seed and skin 130 grams [4½ oz.]; meat alone 260 grams [9 oz.]. From Esparta, 300 to 600 feet above sea level." (Wercklé.)

31479 and 31480. LUCUMA spp.**Sapote.**

31479. "Seed received as a very fine variety. I did not see the fruit, but know that it is *very* good. It is long and large despite the small seed; gray in color." (Wercklé.)

31480. "A splendid long sapote. Weighed about 1 pound; peculiar shape; very highly prized." (Wercklé.)

"A tree 30 to 40 feet high, with fulvous or gray branches, and long obovate leaves. The cream-colored silky flowers are borne in clusters on the stem. Fruit about 6 inches long, with reddish pulp, containing one or more polished seeds. The pulp is sweet and resembles in taste a luscious pear. It is made into a marmalade, which is said to be not unlike good apple preserve." (Macmillan, *Handbook of Tropical Gardening*, p. 152.)

31481. PERSEA AMERICANA Miller.**Avocado.****31482. PHYTOLACCA DIOICA L.****Ombú.**

From Buenos Aires, Argentina. Presented by Mr. Joseph E. Wing, agent of the Tariff Board. Received July 26, 1911.

"This tree does not withstand much frost. It is the common tree of the plains of Argentina and is seen making a dense green mound of verdure in the very dry soils, green during the worst droughts. I have seen them fully 12 feet in diameter; they

make extraordinarily rapid growth, and when cut down, immediately spring into life again, but do not sucker, the growth coming from the trunk. It is a tree much prized for growing near the home of the colonist or estanciero of the plains of Argentina." (*Wing.*)

31483. LINUM USITATISSIMUM L.

Flax.

From Hoshungabad, Central Provinces, British India. Presented by Mr. A. Howard, Quetta, British India, at the request of Mr. J. D. Shanahan, formerly of the Bureau of Plant Industry. Received July 26, 1911.

"As regards the oil-yielding capacity of this variety, I understand it is better than the country linseed, but I believe the yield of seed is less. It may, however, be of use in breeding. It is white seeded." (*Howard.*)

This form was secured at the request of this Office, as it is reported that the Indian white-seeded variety yields 2 per cent more oil than the ordinary dark linseed.

31484. FEVILLEA CORDIFOLIA L.

Cabalonga.

From Costa Rica. Brought in by Mr. José C. Zeledon, San Jose, Costa Rica, July 22, 1911.

"A vine suitable for covering trellises in hot countries, bears a fruit the size of an orange, is an antidote for snake bites, and would grow in Florida." (*Zeledon.*)

"The sequa or cacoon antidote of Jamaica, where it is a common plant in shady woods, climbing to a great height up the trunks of trees. The fruits are 4 to 5 inches in diameter and contain from 12 to 15 large flat seeds which possess purgative and emetic properties and have an intensely bitter taste. In Jamaica the negroes employ them as a remedy in a variety of diseases and consider them to be an antidote against the effects of poison. They also obtain a large quantity of semisolid fatty oil, which is liberated by pressing and boiling them in water." (*Lindley, Treasury of Botany, pp. 490-491.*)

Distribution.—The West Indian islands and in northern South America, extending from Colombia and Peru southward to Chile.

31485 to 31487. ERIOBOTRYA JAPONICA (Thunb.) Lindl. Loquat.

From Rome, Italy. Presented by Mr. G. Eisen, San Francisco, Cal. Received July 27, 1911.

Seeds of the following; quoted notes by Mr. Eisen:

31485. "Fruit large, yellow, 2½ inches in diameter."

31486. "Fruit large, orange, 2½ inches in diameter."

31487. "Fruit pear shaped, 2 inches in diameter."

31488. DIOSPYROS PEREGRINA (Gaertn.) Gurke.

From Sibpur, near Calcutta, India. Presented by Maj. A. T. Gage, superintendent, Royal Botanic Garden, Sibpur. Received July 24, 1911.

"A dense evergreen tree found throughout the greater part of India in shady, wet places and near streams. It is frequently cultivated both for ornament and for its large, red, velvety fruits. The fruit is beaten in a large mortar and the juice expressed. This is boiled, mixed with powdered charcoal, and applied once a year to the outside of the planks of boats. The half-ripe fruits are pounded in a mortar and then kept six or seven days in water until they have decomposed. A gummy solution results, which is poured off. This brownish liquid is used in dyeing and tanning." (*Watt, Commercial Products of India, p. 498.*)

31489 to 31509.

From New Zealand. Presented by Mr. A. H. Cockayne, biologist, Department of Agriculture, Commerce, and Tourists, Wellington, New Zealand. Received July 27, 1911.

"These seeds were collected primarily in connection with the regrassing of denuded areas." (Cockayne.)

31489. *AGROPYRON SCABRUM* (R. Br.) Beauv.

Distribution.—Throughout the islands of New Zealand from sea level up to an elevation of 4,500 feet; also in Australia from Queensland to West Australia and Tasmania.

31490. *AGROSTIS DYERI* Petrie.

"This usually constitutes a large proportion of the subalpine pastures in elevated districts in both islands." (Cheeseman, *Manual of the New Zealand Flora*, 1906, p. 865.)

Distribution.—Mountainous districts at an elevation of 1,000 to 5,000 feet in the islands of New Zealand.

31491. *AGROSTIS* sp.

The seeds of this grass were received under the name *Agrostis tenella*, which was given to the species in 1889 by Petrie (*Transactions of the New Zealand Institute*, vol. 22, p. 442). However, in 1800, Hoffmann (*Deutschlands Flora*, ed. 2, vol. 1, p. 36) had published the name *Agrostis tenella* for a German form of *Agrostis alba*, thus invalidating the use of the same name for the New Zealand grass. As this species has apparently never been given any other name, it seems best to list the material at hand as *Agrostis* sp.

31492. *TRIODIA PUMILA* (Kirk) Hackel.

Distribution.—Mountainous districts of South Island in New Zealand at an altitude of 2,000 to 5,000 feet.

31493. *DANTHONIA BUCHANANI* Hook. f.

Distribution.—In the lake region of the South Island of New Zealand.

31494. *DANTHONIA CUNNINGHAMII* Hook. f.

Distribution.—A handsome grass, often 5 feet high, growing in the islands of New Zealand, ascending to an elevation of 3,500 feet.

31495. *DANTHONIA NUDA* Hook. f.

Distribution.—On the mountain slopes near the eastern coast of North Island, and in dry places among the mountains on the South Island of New Zealand.

31496. *DANTHONIA PILOSA* R. Brown.

Distribution.—The provinces of West Australia, Queensland, and New South Wales in Australia, and in Tasmania and the islands of New Zealand.

31497. *DANTHONIA RIGIDA* Raoul.

Distribution.—Abundant in hilly and mountainous districts up to an elevation of 5,000 feet in the islands of New Zealand.

31498. *CALAMAGROSTIS YOUNGII* (Hook. f.) Skeels.

(*Agrostis youngii* Hook. f. 1867, *Handbook of the New Zealand Flora*, p. 330.)

(*Deyeuxia youngii* Buchanan 1880. *Manual of the Indigenous Grasses of New Zealand*, p. vi.)

The seeds of this New Zealand pasture grass were received under the name *Deyeuxia youngii*. As *Deyeuxia* is not considered to be distinct from *Calamagrostis* and as this species is more closely related to the type of *Calamagrostis* than to the type of *Agrostis*, it is here placed in the former genus.

31489 to 31509—Continued.

31498—Continued.

Calamagrostis youngii was first found on dry hillsides at the source of the Waitaki River in the interior of the South Island of New Zealand, and Buchanan remarks regarding it: "In the district between the Clutha and Matamura rivers, Otago, this grass is abundant and is much eaten by stock." (*Manual of Indigenous Grasses of New Zealand*, p. 61.)

31499. *FESTUCA OVINA* L.31500. *FESTUCA RUBRA* L.31501. *SAVASTANA FRASERI* (Hook. f.) Skeels.

(*Hierochloe fraseri* Hook. f. 1844-45, *Flora Antarctica*, vol. 1, p. 93.)

The seeds of this grass were received from New Zealand under the name *Hierochloe fraseri*. The generic name *Hierochloe* was published by R. Brown (*Prodromus*, p. 208) in 1810, with one species *H. antarctica*. In 1789, however, Schrank (*Baiersche Flora*, vol. 1, pp. 100, 337) had established the genus *Savastana*, with one species, *S. hirta*. This is universally considered to be congeneric with *Hierochloe antarctica* R. Brown. *Savastana* being the older name for the genus, our species is placed here in accordance with present rules of botanical nomenclature.

Savastana fraseri was first found on the slopes of the mountains in Tasmania, and also grows in the mountainous districts of the islands of New Zealand.

31502. *KOBLERIA KURTZII* Hackel.

Distribution.—Abundant throughout the South Island of New Zealand, and also found in Argentina in South America.

31503. *POA AUSTRALIS* R. Br.

The seeds of this grass were received from New Zealand under the name *Poa caespitosa*, which was first used by Forster (*Prodromus*, p. 89) in 1786, but was not described. The first description of the species seems to be by Sprengel (*Mantissa Prima Florae Halensis*, p. 33) in 1807, who published the name *Poa caespitosa* and referred to Forster's *Prodromus*. However, in 1804, Poiret (*Encyclopédie Méthodique Botanique*, vol. 5, p. 73) had published the name *Poa caespitosa* for a grass now considered to be *Poa nemoralis* L. This invalidates the use of the name *Poa caespitosa* by Sprengel in 1807. The next name applied to this species is *Poa australis*, published in 1810 by R. Brown (*Prodromus*, p. 179), the name here used.

"The most abundant grass through wide districts in the South Island, also plentiful in the elevated central portions of the North Island. Unfortunately it is not relished by stock and is seldom eaten, save in the absence of better food. Also in Australia and Tasmania." (*Cheeseman, Manual of the New Zealand Flora*, 1906, p. 908.)

31504. *POA COLENSOI* Hook. f.

"This is one of the most important of the indigenous pasture grasses. It is eaten by all kinds of stock, and is a specially valuable sheep grass in mountain districts." (*Cheeseman, Manual of the New Zealand Flora*, 1906, p. 909.)

Distribution.—Mountain slopes and dry elevated plains rising to an elevation of 7,000 feet, in the islands of New Zealand.

31505. *POA KIRKII* Buchanan.

"This is a valuable grass for all kinds of stock in cool, elevated localities, and is well worth cultivation." (*Cheeseman, Manual of the New Zealand Flora*, 1906, p. 910.)

Distribution.—A variable grass, abundant on the subalpine plains and mountain slopes of the islands of New Zealand.

31489 to 31509—Continued.**31506.** *POA MANIOTOTO* Petrie.*Distribution.*—In the dry plains and broad river basins of the interior of South Island in New Zealand.**31507.** *POA* sp.**31508.** *TRIODIA PUMILA* (Kirk) Hackel.**31509.** *TRisetum ANTARCTICUM* (Forst.) Trin.*Distribution.*—Throughout the islands of New Zealand from sea level up to an elevation of 4,500 feet.**31510. LYCOPERSICON sp.****Tomato.**From Matachin, Chagres River, Canal Zone. Presented by Mr. S. P. Verner.
Received July 27, 1911.

"A native tomato." (Verner.)

31511 to 31536. MALUS SYLVESTRIS Miller.**Apple.**

From New Zealand. Presented by Mr. W. C. Berridge, manager, Tauranga Experimental Farm, Fields and Experimental Farms Division, Department of Agriculture, Commerce, and Tourists. Received July 26, 1911.

Cuttings of the following aphid-resistant or aphid-proof apples:

"Most of the varieties have been proved to be proof against the ravages of the woolly aphid, but several have not yet been fully proved to be absolutely proof against it." (Berridge.)

31511. *Carlton.***31522.** *Lady Hopetown.***31512.** *Cliff's seedling.***31523.** *Lord Wolseley.***31513.** *Coldstream Guards.***31524.** *Magg's seedling.***31514.** *Diadem.***31525.** *Sharp's late red.*

"Not yet proved."

31526. *Taupaki.***31515.** *Early Richmond.***31527.** *Willie Sharp.***31516.** *Edward Lippiatt.***31528.** *Wm. Anderson.***31517.** *Carrington.***31529.** *Yarrabank.*

"Not yet proved."

31518. *Golden Summer Pearmain***31530.** *Sharp's Summer.***31519.** *Irish Peach.***31531.** *Black Spy.*

"Not quite proof. An early variety."

31532. *Commerce.***31520.** *John Sharp.***31533.** *Mayflower.***31521.** *Jupp's Surprise.***31534.** *Sharp's Midseason.*

"Not yet proved. Early."

31535. *Scarlet Queen.***31536.** *William H. E. Sharp.***31537 to 31547. SOLANUM TUBEROSUM** L.**Potato.**

From Chile. Received through Mr. José D. Husbands, Limávida, via Molina, Chile, April 29, 1911.

"Tubers of yellow-fleshed potatoes of wild origin, all from the south along the foothills of the first range of the Cordilleras." (Husbands.)

31548 to 31552. GLYCINE HISPIDA (Moench) Maxim. Soy bean.

From India. Presented by Mr. E. J. Woodhouse, Department of Agriculture, Sabour, Bengal, India. Received July 26, 1911.

Seeds of the following:

- | | |
|----------------------------------|-------------------------------|
| 31548. Chocolate variety. | 31551. <i>Nepali</i> . |
| 31549. Greenish yellow. | 31552. Yellow. |
| 31550. Black. | |

31553. CUPRESSUS GLABRA Sudworth. Cypress.

From Verde River Canyon, Ariz. Presented by Mr. George B. Sudworth, Forest Service, United States Department of Agriculture. Received July 29, 1911.

"Found on the north slopes in moist, rather rich, rocky soil. Elevation of 3,000 to 3,500 feet." (*Sudworth*.)

31554. EUCALYPTUS PATENTINERVIS R. T. Baker.

From Sydney, New South Wales, Australia. Presented by Mr. R. T. Baker, curator, Technological Museum. Received July 31, 1911.

"As the leaves of this tree exhale a pleasant odor it is recommended for park and street cultivation. The timber may be classed as a mahogany, being red, fairly hard, easily worked, and suitable for cabinet work." (*Baker*.)

Distribution.—A medium-sized tree found in the vicinity of Ballina in the north-eastern part of New South Wales, Australia.

31555. ASPARAGUS sp. Asparagus.

From Canary Islands. Presented by Dr. George V. Perez, Puerto Orotava, Teneriffe, who procured them from the head gardener of the Puerto Orotava Botanic Garden. Received July 29, 1911.

Introduced for the breeding experiments of Mr. J. B. Norton, Bureau of Plant Industry.

31556. NYPA FRUTICANS Wurm. Nipa palm.

From Manila, Philippine Islands. Received through Mr. C. V. Piper, of the Bureau of Plant Industry, July 31, 1911.

"This palm is abundant throughout the Malay region, growing especially in brackish marshes near the seashore. It often forms dense jungles, covering large areas, the leaves growing to a height of from 12 to 15 feet. The leaves are almost universally employed for thatching houses, the leaflets being stitched together for this purpose. From the flower stalk the sap is collected by the natives and boiled to obtain the sugar. More commonly this sap is used to manufacture alcohol. This palm will probably be adapted to the coastal conditions in extreme southern Florida." (*Piper*.)

Distribution.—From the Malay Peninsula and Ceylon through the Malay Archipelago to Australia.

31557. ARRACACIA XANTHORRHIZA Bancr. Arracacha.

From David, Republic of Panama. Presented by Mr. J. R. Lastra. Received July 28, 1911.

"A perennial herb of the carrot family. It attains a height of 2 or 3 feet. It has divided leaves like the carrot, small umbels of purple flowers, and has large fleshy roots which form an important article of food in South America and Central America." (*Smith, Dictionary of Popular Names of Economic Plants, p. 95.*)

"Probably best adapted to cultivation in the Southern States, as it is slow in maturing. Well worth the attention of amateurs." (*Fairchild*.)

31558. ANANAS sp.**Ivirá.**

From Paraguay. Presented by Mr. Thomas R. Gwynn, Capilla Horqueta, Departamento de V. Concepcion, Paraguay. Received August 1, 1911.

"I do not know about this being superior to anything in the United States, but I do know if you eat two or three of the crude fruits blood flows from the lips and the teeth are set on edge. Only those can understand who have eaten green apples or sour cherries. The fruit has just the same taste as the cultivated pineapple, is also the same shape, but very small.

"The blade is narrower and the thorns shorter. The leaf is used for its fiber, producing ropes and clothing. Indeed, it is of great value.

"It is a running plant, growing from the roots, piercing in its course almost any obstruction. It is produced from the root or else from the plants formed on top of the fruit, just exactly as the pineapple." (Gwynn.)

Seeds.

31559. STIPA TENACISSIMA Jusl.**Esparto.**

From Paris, France. Purchased from Vilmorin-Andrieux & Co. Received August 10, 1911.

Distribution.—On the plains of the central and southern parts of Spain.

Procured for Mr. Charles J. Brand's experiments with plants for paper stock.

31560. ZEA MAYS L.**Corn.**

From Buenos Aires, Argentina. Presented by Mr. Joseph E. Wing, of the United States Tariff Board. Received July 26, 1911.

"I bought this Argentine maize in Buenos Aires. It may be quite useful in our country in regions like western Nebraska or Colorado, since it matures here in a climate that will not mature our maize, owing to cold nights and drought." (Wing.)

31561 and 31562. LYCOPERSICON spp.**Tomato.**

From Peru. Presented by Dr. A. Weberbauer, German Legation, Lima, Peru. Received August 1, 1911.

Seeds of the following; quoted notes by Dr. Weberbauer:

31561. "Plant small, half a meter [20 in.] high, a half shrub with yellow flowers. Fruit as large as that of *Sorbus aucuparia*. Found above Lomas Harbor, at 1,000 to 1,100 meters [3,300 to 3,600 ft.]. Grows in a hot, almost rainless, entirely frost-free region in the dry bed of a stream which sometimes receives water from the rain falling in the higher mountains."

31562. "A climbing shrub 3 meters [9½ ft.] high, with yellow flowers. Fruit as large as that of *Amygdalus persica*; green. Grows in a lateral valley of the river Apurimac in the vicinity of Andahuaylas, at about 2,600 meters [8,500 ft.]. Climate warm, generally frost free. From November to April it rains freely; from May to October there is almost none. The plants, however, grow always on the banks; they live likewise on soils constantly moist, but not swampy."

31563 to 31567. NICOTIANA TABACUM L.**Tobacco.**

From Mexico. Presented by Mr. George Young, secretary, Cananea Consolidated Copper Co., Cananea, Sonora, Mexico, who procured them from Juan Esteva & Son, Alvarado, Vera Cruz, Mexico. Received August 2, 1911.

Seeds of the following; quoted notes by Esteva & Son:

31563. "*Tabaco de Monte.*"

31563 to 31567—Continued.

31564. "*Huimanguillo*. This is grown in places rather warm, and its good quality as well as the peculiarity of being nicotinous, which, as you are aware, is an advantage in certain kinds of this weed and in the case of this plant is apt to be blended with other materials, is due, in our opinion, to the richness of the soil in which it is cultivated. This plant soon robs the soil of its nourishment and at the end of a certain number of years requires renovation of the soil unless the same is properly fertilized."

31565. "*Ozumacin*. This variety of tobacco is grown in a warm climate and in a soil that is somewhat distant from the river bank, as it is claimed that tobacco grown at a short distance from the water has an acrid and bitterish taste."

31566. "*Simojovel*. This variety grows wild and the Indians follow the practice of cutting its leaves little by little, according to the condition of the plant."

31567. "*Valle Nacional*. This variety is grown in a temperate climate and the elasticity of its leaves on being wet is due to this fact, as is also the color of its leaves and their freedom from stain, although this generally depends on the care which is being taken at the time of cutting them; it is necessary to protect the plant from the sun after a shower has fallen, otherwise the leaves will be covered with yellow spots which we call 'pinta de agua' (water-mark)."

31568 to 31570. (Undetermined.)

From Chile. Received through Mr. José D. Husbands, Limavida, via Molina, Chile, April 29 and June 22, 1911.

Bulbs of the following; quoted notes by Mr. Husbands:

31568. "(H. No. 1150 and 1151.) A carmine-red. Blazing flowers of good size. Plant, dwarf; late; good."

31569. "(H. No. 993.) Crimson with white stripes; fall flowering. Grows in the baked clays of central Chile."

31570. "(H. No. 991 and 992.) Crimson. Dwarf plant. Flowers in the summer. Thrives in dry sands or soils. From V. Antuco."

31571. SYZYGIIUM CUMINI (L.) Skeels.

(*Myrtus cumini* L. 1753, Species Plantarum, p. 471.)

(*Eugenia jambolana* Lam. 1789, Encyclopédie Méthodique Botanique, vol. 3, p. 198.)

The seeds of this East Indian myrtaceous tree were received under the name *Eugenia jambolana*, which was given to the species by Lamarck in 1789. However, Linnaeus, in 1753, had given the name *Myrtus cumini* to a tree from Ceylon, and the specimen on which this name was based is preserved in the British Museum herbarium, and was identified in 1887 by H. Trimen (Journal of the Linnean Society, Botany, vol. 24, p. 142) as *Eugenia jambolana* Lam. This species being now considered to belong to the genus *Syzygium*, the earlier specific name is here placed in that genus in accordance with present rules of botanical nomenclature.

From Philippine Islands. Presented by Mr. C. V. Piper, of the Bureau of Plant Industry. Received July 26, 1911.

"*Duhot* or *Lunaboy*. A large tree, in common cultivation. Ripe fruit black, oblong, nearly 1 inch long; stone large. Flavor when ripe like a Black Republican cherry;

when unripe is quite astringent. Fruit in clusters of 10 to 40. Near Manila the fruit ripens from May 15 to June 15." (*Piper*.)

Distribution.—Found throughout India and Ceylon and extends through the Malay Archipelago to Australia. It also occurs under cultivation in the West Indies.

31572 to 31576.

From Costa Rica. Presented by Mr. Carlos Wercklé, San Jose, Costa Rica. Received August 4, 1911.

Cuttings of the following; quoted notes by Mr. Wercklé:

31572 and 31573. *MANGIFERA INDICA* L. **Mango.**

31572. "*Gran cazique* (Great Chief). Fruit very large; crimson and violet in color; few fibers; best quality; very fertile."

31573. "Fruit very large and beautiful; carmine and violet in color; solid, few fibers, much meat; best quality; very fertile."

31574 to 31576. *ANNONA* sp. **Annona.**

"From San Francisco, Nicaragua. Fruit delicious. Trees bear the second year. These cuttings are from three differently shaped trees. No. 31574 is a seedling, and is considered the best."

31577 to 31608.

From Philippine Islands. Received through Mr. C. V. Piper, of the Bureau of Plant Industry, July 26, 1911.

Seeds of the following; notes by Mr. Piper:

31577. *BRYONOPSIS LACINIOSA* (L.) Naudin.

"From Davao, May 14, 1911. A slender, cucurbitaceous vine with pretty leaves. Perhaps of ornamental value. Fruits size and shape of a pecan, yellow."

Distribution.—Throughout the tropical regions of Africa, Asia, the Malay Archipelago, and Australia.

31578. *CAJAN INDICUM* Spreng. **Pigeon-pea.**

"Purchased in the market at Jaro, Panay, May 3, 1911. The speckled seeds are probably hybrids between the black and the white."

31579. *CLERODENDRUM CUMINGIANUM* Schauer.

"From La Carlota, Negros, May 1, 1911. A luxuriant, herbaceous plant with large, velvety cordate leaves. Panicle purple, remaining so in age."

31580. *CLERODENDRUM INTERMEDIUM* Chamisso.

"From La Carlota, Negros. A beautiful, luxuriant herb growing 6 to 10 feet tall, with large, opposite, cordate, somewhat dentate, leaves. Panicle large, scarlet, the calyx and peduncles remaining so for a long time. Should make a fine tropical annual plant."

Distribution.—Known only from the Philippines.

31581. *CROTALARIA SALTIANA* Andrews 1811.

(*Crotalaria striata* Schrank 1828.)

"From Iloilo, May 6, 1911. A half-shrubby bush, 3 to 6 feet high."

Distribution.—Throughout tropical and southern Africa and in tropical Asia and South America.

31582. *GOSSYPIMUM* sp. **Kidney cotton.**

"A variety found on the island of Marinduque. A company testing it has 12 acres planted and has high hopes of it. Apparently a form of *Gossypium braziliensis*. Prof. Conner, of the Manila Bureau of Agriculture, says they have obtained the same sort from various islands of the Philippines."

31577 to 31608—Continued.**31583. Gossypium NANKING** Meyen.**Cotton.**

"From Argao, Cebu, April, 1911."

31584. MOMORDICA OVATA Cogn.

"A peculiar cucurbit with subglobose, spiny fruits about the size of a lemon. Said to be used as a headache cure. Cultivated at Cagayan, Misamis; collected April 29, 1911."

Distribution.—Found in the Philippine and Celebes Islands.

31585. ORMOSIA CALAVENSIS Azaola.

"A locustlike tree from Siquijor, May, 1911."

Distribution.—Known only from the Philippines.

31586. PAHUDIA RHOMBOIDEA (Blanco) Prain.

"*Balayong* or *Tindalo*. A valuable timber tree. Seeds used for some medicinal purpose. These were purchased in the market at Batangas, Luzon."

Distribution.—Known only from the Philippines.

31587. CRACCA DICHOTOMA (Desv.) Kuntze.

"Stems slender, suberect, 2 to 3 feet high. Seed habits excellent."

Distribution.—Known only from the Philippines.

31588. TRICHOSANTHES QUINQUANGULATA A. Gray.

"A cucurbitaceous vine with beautiful, globose, smooth, red fruits as large as an orange. From San Miguel, Tarlac, June, 1911."

Distribution.—Known only from the Sulu Archipelago in the Philippines.

31589. MANIHOT ESCULENTA Crantz.**Cassava.**

"A native variety grown at the Los Banos Agricultural College. Earliest variety found here, maturing in five months. Roots sweet. Presented by Dr. E. B. Copeland."

Distribution.—A herbaceous plant with tuberous roots found in a wild state in Brazil and generally cultivated in the Tropics.

31590. HETEROSPATHE ELATA Scheff.**Palm.**

"A tall, graceful palm cultivated at Argao, Cebu. Leaves pinnate, recurved. Panicle large, drooping. Also seen wild near Cabadbaran, Mindanao."

Distribution.—An erect, unarmed palm, found in the Molukkas and the Philippines.

31591. ARUNDINELLA SETOSA Trin.

"Tall, erect, not very leafy, grows 3 to 4 feet high, of about the habit of tall meadow oat-grass. Stock are apparently not fond of it. Seed habits good. From Baguio, April 10, 1911. Should be tested at Biloxi, Miss.; Chico, Cal.; and Arlington Farm, Va."

Distribution.—From the western Himalayas, where it reaches an elevation of 5,000 feet, southeastward through India and China to the Philippines.

31592. CANALI sp.

"From the seashore of Davao, May 14, 1911."

31593. CROTALARIA INCANA L.

"A bushy, half shrubby, annual (?) legume forming plants 3 to 6 feet high and 2 to 4 feet across. Flowers yellow. Producing seeds in abundance. Manila, April, 1911."

Distribution.—Throughout the Tropics, either naturalized or cultivated; probably a native of the West Indies.

31577 to 31608—Continued.**31594. MEIBOMIA HETEROCARPA (L.) Kuntze.**

"From Hinatuan, Surigao Province, Mindanao, May 13, 1911. Suberect, 3 to 4 feet high, very fruitful. Perennial (?). Stems hard but not woody."

Distribution.—Southeastern Asia, extending from the Himalayas in northern India eastward through Burma and Malakka to China and Japan, and throughout the Malay and Polynesian archipelagoes to Australia.

31595. SYNTERISMA CILIARIS (Retz.) Schrad.**Crab-grass.**

"From La Carlota, Negros, May, 1911. Much larger than our common crab-grass but of same habit and value. To be tested at Biloxi, Miss., and Arlington Farm, Va."

31596. CAPRIOLA DACTYLON (L.) Kuntze.**Bermuda grass.**

"From Lamao, June, 1911. A small crab-grass forming pure growths and becoming 12 to 18 inches high.

31597. ERIOCHLOA RAMOSA (Retz.) Kuntze.

"From Alabang, May 28, 1911. A common grass in rather low ground. Stems slender, fairly erect. Seed shatters easily. Of value only as a pasture grass, provided it will spread."

Distribution.—The plains of India and generally distributed in the Tropics.

31598. ECHINOCHLOA COLONA (L.) Link.

"From Lamao, June, 1911. This volunteers in cultivated fields like crab-grass. Cattle and carabao eat it readily."

31599. PANICUM DISTACHYON L.

"From Lamao, June, 1911. A grass forming great, loose mats 2 to 6 feet across. When growing thickly it becomes 18 inches high. Apparently of considerable value as a pasture grass, especially in sandy soil."

Distribution.—The plains of India and eastward to China and through the Malay Archipelago to Australia.

31600. PASPALUM LONGIFOLIUM Roxb.

"From San Miguel, Tarlac, May 30, 1911. A perennial tufted species."

Distribution.—Throughout the warmer parts of India and generally scattered in the Tropics.

31601. PROSOPIS JULIFLORA (Swartz) DC.**Algaroba.**

"A species much like our common mesquite, quite abundant around the shores of Manila Bay. The pods are not nearly so good as the Hawaiian mesquite, but cattle are said to eat them. Mr. Merrill, of the Manila Bureau of Agriculture, is pretty certain that it is not native, but an introduction from America, perhaps changed by its environment here."

31602. STIZOLOBIUM sp.

"Found in woods near La Carlota, Negros, May 1, 1911."

31603. STIZOLOBIUM sp.

"From Bosoc, Negros, May, 1911."

31604. STIZOLOBIUM PRURIENS (Stickm.) Medic.

"This may be identical with No. 31602, but is probably different."

31605. SYNTERISMA CILIARIS (Retz.) Schrad.**Crab-grass.**

"Much like the common crab-grass, but larger and more vigorous."

31577 to 31608—Continued.**31606. VIGNA LUTEA** (Swartz) A. Gray.

"A luxuriant species growing on and near the strand at Tacloban, Leyte. Habit that of a very viny catjang. Flowers yellow. The best Vigna I have seen outside of the cultivated ones. In one place this seemed to be cultivated and the seeds are said to be eaten."

Distribution.—Originally described from Jamaica; cosmopolitan in the Tropics.

31607. VIGNA LUTEA (Swartz) A. Gray.

"Grows on the strand at Surigao, also at Tacloban, Davao, and Tandag. Forms running vines 6 to 12 feet long and under favorable conditions grows up shrubs to a height of 12 to 15 feet. Very vigorous and quite fruitful. No disease."

31608. VIGNA SINENSIS (Torner) Savi.**Cowpea.**

"Purchased in the market at Jaro, Panay, May 3, 1911."

31609 to 31612. MEDICAGO spp.

From Chile. Received through Mr. José D. Husbands, Limavida, via Molina, Chile, April 21, 1911.

Seeds of the following; quoted notes by Mr. Husbands:

31609. MEDICAGO ARABICA (L.) All.

The size and venation of the pods are the same as in the species, but the spines are wanting or reduced to small tubercles, bridging the dorsal ridges of the pod.

"A new beardless type."

31610. MEDICAGO ARABICA (L.) All.

"An old bearded sort."

31611. MEDICAGO HISPIDA RETICULATA (Benth.) Urban.

"A new beardless sort."

31612. MEDICAGO HISPIDA DENTICULATA (Willd.) Urban.

"The same as the preceding, but bearded."

"The country people are aware of two kinds of seed pods, i. e., beardless and bearded, but they think that it is the same plant that produces them and that more or less prickles are due to moisture conditions. Everyone says there is but one kind. I found a very few plants by patient search and was able to obtain four kinds. Each kind of seed is from a separate and distinct plant.

"In their dry states the plant characteristics could not be studied. I am convinced that a study of the live plants will reveal many varieties to which scientific attention has not been given. Roaming about I have often noticed the great variations in this plant, the distinct black markings or lack of them, the varied form of leaves and plant, the degrees of growth from flat on the ground to 5 feet high, with many intermediate growths side by side in the same soil, while both the bearded and the beardless sorts grow together in dry and moist or irrigated lands, the proportion of each being marked.

"In the 'vegas,' or moist plains, which adjoin the foothills and also growing wild in irrigated fields, planted with corn, potatoes, beans, peas, pumpkins, etc., the bearded sorts predominate, and the beardless sorts are scattered sparingly among them. On the contrary, in the dry farm lands the beardless varieties prevail in like proportions. This suggests the fact that the beardless has an affinity for dry lands, which may be useful to follow with a view of producing a dry-land alfalfa.

"Botanists say that these seeds were introduced from Europe. This is hard to believe. It seems to me that no plant has the *chilensis* brand more clearly marked; I have found stray plants in the most remote parts of Chile, in the Cordilleras far away from civilization, and the possibility of being the product of seeds from other localities. Its distinctly different type in every respect and varied in each locality all go to show its indigenous character."

31613. THESPESIA POPULNEA (L.) Solander. Suriya.

From the Philippine Islands. Received through Mr. C. V. Piper, of the Bureau of Plant Industry, August 8, 1911.

"A shrub or small tree with large, yellow, trumpet-shaped blossoms. Cultivated more or less as an ornamental." (Piper.)

31614. PERSEA AMERICANA Miller. Avocado.

From Livingston, Guatemala. Presented by Mrs. Lucie Potts. Received August 24, 1911.

Supposed to contain different varieties.

31615. MANGIFERA INDICA L. Mango.

From Costa Rica. Presented by Mr. Carlos Wercklé, San Jose, Costa Rica. Received August 9, 1911.

"Rio Grande. Best variety. Very big. Best quality." (Wercklé.)
Seeds.

31616. PERSEA AMERICANA Miller. Avocado.

From Guatemala, Central America. Presented by Mr. S. Billow, Guatemala. Received August 9, 1911.

"These seeds are from Amatitlan, about 24 miles from the capital city and grown at an altitude of 3,800 feet; the meat is of a delicious flavor and the avocados weigh nearly three-fourths of a pound. These seeds are selected from the best grown in that district." (Billow.)

31617. MEDICAGO sp.

From near Baba, northwestern Mongolia. Received through Mr. Frank N. Meyer, agricultural explorer, August 10, 1911.

"(No. 1618a, May 1, 1911.) (*Medicago falcata* ?.) An alfalfa that reaches a height of apparently not over 2 feet. Found growing here and there in large quantities on hills, between dense grass at altitudes of about 4,000 feet. As the cold gets very intense in these regions, these plants may be tested in the most northern sections of the United States." (Meyer.)

31618 to 31630.

From Canal Zone. Presented by Mr. Ramón Arias-Feraud, Panama. Received August 10, 1911.

31618. ANANAS SATIVUS Schult. Pineapple.

"Suckers of the genuine *Taboga* pineapples, which are considered the best flavored in this region. They are getting scarce because they do not grow as large as other varieties, and as the leaves are covered with plenty of spines the planters prefer to handle the larger fruits that are free from the spines."

31618 to 31630—Continued.**31619. GARCINIA sp.****"Monkey-fruit."**

"A beautiful evergreen tree, the fruit of which the boys like very much. The seeds are enveloped and the inner shell lined with a milky white pulp, which is chewed and which has a peculiar sweet, acid taste. There is a larger variety of this fruit that is still better, but the crop has already passed. I brought these plants from the Cordilleras about 10 years ago, in seeds, and they have begun to bear now. They are not found near the surroundings of the town, but out on the mountains." (*Arias-Feraud.*)

31620 to 31630. MANGIFERA INDICA L.**Mango.**

From "El Carmen" orchard, Las Sabanas, Canal Zone.

31620. Green.**31625. Kidney.****31621. Quality No. 2.****31626. Round.****31622. Red Apple.****31627. Soft, sweet.****31623. Pico de Pajaro.****31628. Common quality.**

(Bird's Beak.)

31629. Pineapple.**31624. Thick skin.****31630. Assorted mangos.****31631. PERSEA AMERICANA Miller.****Avocado.**

From Chile. Received through Mr. José D. Husbands, Limavida, via Molina, Chile, August 14, 1911.

Probably Mr. Husbands' No. 1325 of which he says:

"*Paltas*. These seeds are from fruits selected from among all the best varieties growing in Quillota as the best of all, having smaller seeds, thicker flesh, and the most delicious flavor of any. Trees grown from seed fruit in five years. Believed to come true from seed, but nothing is scientifically known about it." (*Husbands.*)

31633 and 31634.

From Peradeniya, Ceylon. Presented by Dr. John C. Willis, director, Royal Botanic Gardens, Peradeniya. Received August 14, 1911.

Seeds of the following:

31633. MANGIFERA ZEYLANICA (Blume) Hook. f.

Distribution.—A tree found on the island of Ceylon up to an elevation of 3,000 feet.

31634. SPONDIAS PINNATA (L.) Kurz.

See Nos. 30491 and 30627 for previous introductions.

31635 to 31637.

From Costa Rica. Presented by Mr. Carlos Wercklé, San Jose, Costa Rica. Received August 14, 1911.

Seeds of the following; quoted notes by Mr. Wercklé:

31635. BOMAREA sp.

"*Papa de venado* (Dear potato). Edible roots. Quite productive. Grows near frost line."

31636. COCCOLOBIS UVIFERA L.**Sea-grape.**

"*Papaturros*. Improved large-fruited. For crossing with the *carrocaliente*" (See No. 31931, *Coccolobis* sp.).

31637. COUEPIA POLYANDRA (H. B. K.) Rose.**Yellow sapote.**"The famed *sapotilla de olor*."

Distribution.—A tree, belonging to the rose family, found in the vicinity of Acapulco on the Pacific coast of southern Mexico.

31638. DIOSCOREA sp.

From Chile. Received through Mr. José D. Husbands, Limavida, via Molina, Chile, August 15, 1911.

"*Haiaque*. A dainty vine elegant for window or table decoration. Tubers edible when cooked." (*Husbands*.)

31639. RHUS VERNICIFLUA Stokes.**Lacquer tree.**

The lacquer tree has heretofore been listed in these inventories as *Rhus vernicifera*, which was published in 1825 by De Candolle (*Prodromus*, vol. 2, p. 68). In 1796, however, Salisbury (*Prodromus*, p. 169) published the name *Rhus verniciferum*, based on *Rhus vernix* L., thus invalidating the use of the same name by De Candolle. *Rhus vernix*, published in 1753 by Linnæus (*Species Plantarum*, p. 265) included two distinct species, the poison sumac of America and the lacquer tree of Japan. In 1771, Linneus (*Mantissa Plantarum*, p. 358) excluded the Japanese plant from *R. vernix*, thus showing that he wished the name to apply to the American plant. As no other name had been published for either of these plants up to this time there is no reason why this should not be followed. In 1812, Stokes (*A Botanical Materia Medica*, vol. 2, p. 164) called attention to this fact in a note under his description of *Rhus verniciflua*, which is apparently the earliest name published for the lacquer tree, and is the one here used.

From Japan. Presented by Mr. Thomas Sammons, American consul general, Yokohama, Japan, who procured them from Mr. Metsunosuke Yamaguchi, Shindamachi, Nagano, Nagano Prefecture, Japan. Received July 26, 1911.

"A slender-branched tree with winged leaves, attaining a height of 20 feet. It is common throughout Japan and is cultivated for its sap, which flows from its stem and branches on being wounded. It is first cream colored, but on exposure to the air soon turns black, and is the varnish which the Japanese use for lacquering their furniture or ornamental articles." (*Smith, Dictionary of Popular Names of Economic Plants*, p. 426.)

"The varnish or lacquer is valuable because of its great hardness without brittleness or becoming cracked, its high lustre and mirrorlike surface, which remains untarnished for centuries, its resistance to the agencies which attack resinous varnishes, as it is not injured by boiling water, hot ashes, hot alcoholic liquors, acids, etc." (*J. J. Rein, Industries of Japan*.)

"Unlike ordinary paints, which dry because of oxidizing properties of the oil in them, this Japanese lacquer dries better in moist than in dry air, as the result of a supposed enzyme which acts upon an albuminoid in the presence of a vegetable-acid and a gum.

"Experiments have shown that lacquer will not harden if subjected to temperatures which are high enough to coagulate the albumen. From a painful personal experience with some of the imported juice of this tree I can warn anyone not to experiment with it unless he is immune to ivy poisoning. Here would seem to be an opportunity to discover means by which with the use of proper face and hand lotions workers could handle the lacquer with impunity. Certainly, so wonderful a thing as this lacquer industry should not go without investigation because of its poisonous properties." (*Fairchild*.)

Experimenters with this tree should remember that the volatile sap causes a painful eruption on the skin of certain persons similar to that caused by the species of our common *Rhus* known as poison ivy, though probably more intense even than the latter.

Distribution.—On the wooded slopes of the mountains in the islands of Japan and in the provinces of Ichang, Shensi, and Szechwan in China.

31640. JUGLANS REGIA L.**Walnut.**

From Chile. Received through Mr. José D. Husbands, Limavida, via Molina, Chile, June 12, 1911.

"A large Chile variety of accidental origin from Chile-grown seed. The year was one of extreme drought and therefore the nuts are smaller and with less meat than usual." (*Husbands.*)

31641. CUCURBITA sp.**Squash.**

From Paraguay. Presented by Mr. C. F. Mead, Villa Encarnacion, Paraguay. Received August 14, 1911.

"*Zapallo*. I consider this a very ordinary variety. These zapallos have no distinguishing names; all are just zapallos, or squash in English." (*Mead.*)

31642. LUCUMA OBOVATA H. B. K.

From Chile. Received through Mr. José D. Husbands, Limavida, via Molina, Chile, August 14, 1911.

"*Lucuma de Quillota*. The skin of this fruit is a bright, dark green, flesh yellow, very much like a pumpkin but lighter colored and more mealy." (*Husbands.*)

Distribution.—The provinces along the coasts of Peru and Chile.

31643 to 31645.

From Seharunpur, India. Presented by Mr. A. C. Hartless, superintendent, Government Botanical Gardens, United Provinces. Received August 15, 1911.

Seeds of the following:

31643. BAMBUS ARUNDINACEA Retz.**Bamboo.**

See No. 21317 for description.

31644. DIOSPYROS MONTANA Roxb.

Distribution.—From the Himalayas to Ceylon in India, and through the Malay Archipelago to tropical Australia.

31645. CHALCAS PANICULATA L.**31646 to 31649.**

From India. Presented by Mr. A. C. Hartless, superintendent, Government Botanical Gardens, United Provinces, Seharunpur. Received August 15, 1911.

Seeds of the following; notes furnished by collector and transmitted by Mr. Hartless:

31646 and 31647. MELILOTUS ALBA Desr.**Sweet clover.**

31646. From Ladakh.

31647. Locality not given.

31648. MEDICAGO SATIVA L.**Alfalfa.**

"*Bu-Kusk*, from Iskardo. This variety once cultivated remains for at least 8 or 9 years, provided that bhail (manure) is thrown on it and it is not trodden upon. Its flower is of blue color. It is of short stature with thin branches. Animals eat it with great pleasure. If, when green, animals eat it, it does no harm."

31649. MEDICAGO FALCATA L.

"*Boole-Bu-Kusk*, from Iskardo. This variety once cultivated remains for at least three or four years. If it is given to animals when green, it swells their stomachs. Its flower is yellow in color, and its plant is larger than that of the preceding number, but animals do not like it as well."

31651. CITRUS MEDICA L.**Citron.**

From Villa Rica, Paraguay. Presented by Mr. C. F. Mead, Villa Encarnacion, Paraguay. Received August 18, 1911.

"These citrons were found in a shipment of oranges, etc., from Villa Rica. Whether they are out of the ordinary or not I can not say. Largest citron weighed 4½ pounds, 22 inches in circumference the long way by 13 inches in circumference around the center. When conditions are excellent for growth, fruits up to 12 inches in length are not uncommon. The plant is of scraggly growth, the branches reaching down to the ground if not pruned and sprouting wherever they touch. The peel is used to some extent here for preserves." (Mead.)

31652 and 31653.

From Pietermaritzburg, Natal, South Africa. Presented by Mr. W. J. Newberry, curator, Botanic Gardens. Received August 18, 1911.

Cuttings of the following:

31652. PRUNUS sp.**Plum.**

"*Methley*. This originated near Mr. Methley's homestead, the original tree being a volunteer and growing near a spruit hard by. This seedling, to-day the parent of thousands growing throughout the colony, attracted attention directly it first fruited, owing to the earliness with which the plums ripened; that is, at the same time as our local myrobalan (myrobalan is used throughout as a group name), possibly the *Marianna* and frequently but erroneously called the *Mirabelle*.

"The virtue of the *Methley* is its early ripening. It possesses the good characters of the *Satsuma*, but is deficient in point of size.

"There is every reason to believe that the plum originated from the fertilizing of *Satsuma* flowers by myrobalan pollen, the male element transmitting the smaller size and earliness of ripening and not impairing with myrobalan faults the flavor and texture of the *Satsuma*.

"From inquiries it seems that some blood plums were sent to Mr. Methley from another farm from trees growing in juxtaposition to myrobalans. After this lot of fruit had been partaken of, the stones were thrown out. From one of these pits washed down toward the sluic by the weather it is assumed the original *Methley* grew. As no other adventitious plums came into being, it is rather interesting to speculate upon this one survival, which may, of course, have been the only cross-pollenized seed of the lot.

"The color of the fruit is dark red, ripening to darker red; dots numerous, russet, areolar; bloom, whitish or bluish; flesh, dark red, firm; stone, medium in size, cling; flavor and quality good; season very early; thrives on peach stock." (Extract from C. Fuller in *Natal Agricultural Journal*, vol. 14, 1910, pp. 279-280.)

31653. MALUS sp.**Apple.**

Wainwright. "A good subtropical apple." (Newberry.)

31654. OXALIS sp.

From Chile. Received through Mr. José D. Husbands, Limavida, Chile, August 14, 1911.

"*Chapeola*."

Tubers.

31655 to 31676. SOLANUM spp.**Potato.**

From Chile. Received through Mr. José D. Husbands, Limavida, via Molina, Chile, August 14, 1911.

Tubers of the following; quoted notes by Mr. Husbands:

"These potatoes, sorts that are cultivated by the Indians, all of wild origin, are from the wild country of the interior of Llanquihue. The Indian names have little significance, as the same names may be used for other kinds of potatoes by distant tribes or the same tubers called other names."

31655 to 31665. "White and semiyellow kinds."

31655. " <i>Guicofas</i> ."	31662. " <i>Haurunas</i> ."
31656. " <i>Ojosos</i> , smooth."	31663. " <i>Puineriza rosada</i> (pink). Very early; said to yield potatoes in seven weeks."
31657. " <i>Coraila</i> , white."	
31658. " <i>Pedanes</i> ."	
31659. " <i>Bolera blanca</i> ."	
31660. " <i>Guafas</i> ."	31664. " <i>Murtá</i> ."
31661. " <i>Yacuis azules</i> ."	31665. " <i>Libra</i> ."

31666 to 31676. "Yellow-fleshed varieties."

31666. " <i>Palmata</i> ."	31673. " <i>Pelchuquina</i> ."
31667. " <i>Panas</i> ."	31674. " <i>Sieta semana rosada</i> . Pink skin; very early; said to give potatoes in seven weeks."
31668. " <i>Araucana mus- ca</i> ."	
31669. " <i>Chilota</i> ."	
31670. " <i>Ocas</i> ."	31675. " <i>Vigochas</i> ."
31671. " <i>Almud</i> ."	31676. " <i>Piconas</i> . Extra early."
31672. " <i>Cauchan</i> ."	

31677 to 31679. JUNIPERUS UTAHENSIS (Engelm.) Lemmon.**Juniper.**

Received through Mr. George B. Sudworth, dendrologist, Forest Service, U. S. Dept. of Agriculture, August 19, 1911.

Seeds of a very attractive southwestern juniper:

31677. From Yavapai County, Ariz., October, 1910.

31678. From southern Utah, December, 1910.

31679. From the Grand Canyon of the Colorado River, Ariz., November, 1910.

Distribution.—In the desert region between the Rocky Mountains and the Sierra Nevada, from southern Wyoming southwestward through eastern Utah and western Colorado to northern Arizona and southeastern California.

31680. GOSSYPIUM DRYNARIOIDES Seemann.**Cotton tree.**

From Hawaii. Presented by Mr. Ralph S. Hosmer, Superintendent of Forestry, Honolulu, at the request of Dr. E. V. Wilcox, Hawaii Agricultural Experiment Station, Honolulu. Received August 14, 1911.

"I have learned that at the 'west end of Molokai,' in the driest locality of the island, where this plant was originally collected by Nelson, the companion of Capt. Cook, there is only one tree in existence and that is half dead. A new locality on the island of Hawaii has been discovered and six trees are still growing on the slopes of the volcano Hualalai on rough lava fields at an elevation of 2,000 feet. The trees are

from 15 to 25 feet high and when covered with large scarlet flowers are of striking beauty. If not properly protected they will soon be a thing of the past, as the natives strip the trunks of the bark for the rich reddish brown sap used by them for dyeing their fish nets. Cattle are also very fond of the leaves. The plants from the island of Hawaii differ so much from those on Molokai as to need a new varietal name." (*Joseph F. Rock, Botanist, College of Hawaii, Honolulu.*)

31681 and 31682. *PITTOSPORUM* spp.

From Hawaii. Presented by Mr. Ralph S. Hosmer, Superintendent of Forestry, Honolulu, at the request of Dr. E. V. Wilcox, Hawaii Agricultural Experiment Station, Honolulu. Received August 14, 1911.

Seeds of the following:

31681. *PITTOSPORUM* *HOSMERI* Rock.

"This species is remarkable for the unusually large woody capsules which open into two, three, and sometimes four valves. Native name *Aawa hua kukui*. The fruits exude a milky glutinous sap." (*Report of the Division of Forestry, Territory of Hawaii, for the Biennial Period Ending December 31, 1910, p. 84.*)

Distribution.—This tree is rather common on the lava fields of Puuwaawaa, Hawaii, at an elevation of 3,000 feet.

31682. *PITTOSPORUM* *KAWAIENSE* Hillebrand.

Distribution.—A tree usually about 30 feet high, growing on the slopes of the mountains in the vicinity of Waimea on the island of Kauai in Hawaii.

31683. *SOLANUM* sp.

Potato.

From Perene, Peru. Presented by Mr. J. A. Furlong. Received August 18, 1911.

"*Shiri*, or bitter potatoes." (*Furlong.*)

Tubers.

31684. *PHOENIX* *DACTYLIFERA* L.

Date.

From Morocco. Purchased from Barrow, Lane, & Ballard (Ltd.), London, England. Received August 18, 1911.

Tafelt. See No. 18630 for description.

Seeds.

31685. *ERAGROSTIS* *PECTINACEA* (Michx.) Nees.

From Ainsworth, Nebr. Presented by Mr. G. J. Kimball, through Mr. H. N. Vinall, of the Bureau of Plant Industry. Received August 21, 1911.

"One of the grasses which seems to be of most promise for seeding in the sand hills of Nebraska." (*Vinall.*)

Distribution.—In dry, sterile soil from New Hampshire to Florida and westward to South Dakota and Texas in the United States, and southward in Mexico to Vera Cruz.

31686. *LICANIA* *PLATYPUS* (Hemsl.) Fritsch.

From San Jose, Costa Rica. Presented by Mr. C. Wercklé. Received August 21, 1911.

"*Sansapote.*"

Distribution.—A tree found in Central America from Nicaragua, where it is cultivated, southeastward through Costa Rica and Panama to Colombia.

31687. MEDICAGO SATIVA L.**Alfalfa.**

From Chugutchak, Mongolia. Received through Mr. Frank N. Meyer, agricultural explorer, August 18, 1911.

"(No. 1617a, May 16, 1910.) A strain of alfalfa said to be much hardier than the ordinary varieties, but also said to be of slower growth. While fields sown to imported Turkestan seed give three cuttings a year in Chugutchak, this variety gives but two, but while one-third of the plants of the Turkestan alfalfa are killed in a severe winter, this strain is said not to suffer at all. It should be tested in a cool and dry region of the United States, especially in Wyoming, Montana, Idaho, etc. This seed was saved by a Sart farmer from his own plants and obtained through the assistance of the Russian Aksakal at Chugutchak." (Meyer.)

31688 to 31697.

Received through Mr. Frank N. Meyer, agricultural explorer, August 18, 1911.

Seeds of the following:

31688. MALUS sp.**Apple.**

From mountains near Kulja, Chinese Turkestan.

"(No. 1619a, April 20, 1911.) Very hardy wild apples, collected in semiarid mountains at altitudes between 5,000 and 6,000 feet above sea level. The trees growing at 4,500 feet were in bloom at time of visit, but those at altitudes between 5,500 and 6,000 feet above sea level were perfectly dormant. To be used as hybridization material in creating hardier varieties which will be able to stand better than most of the present strains, the climate of the upper Mississippi Valley and the regions west of it. See also Nos. 968 to 971 (S. P. I. Nos. 30946 to 30949) in connection with this." (Meyer.)

31689. MALUS sp.**Apple.**

From Saisanak, southern Siberia.

"(No. 1620a, May 29, 1911.) An apple, said to grow in gardens around Saisanak; apparently seedlings from wild varieties, occurring in the mountains. The remarks made under Nos. 968 to 971 and 1619a (S. P. I. Nos. 30946 to 30949 and 31688) also apply to this one." (Meyer.)

31690. MALUS sp.**Apple.**

From Saisanak, southern Siberia.

"(No. 1621a, May 29, 1911.) A small apple of bright-red color and possessing a most excellent flavor. Said to be grown sparingly near Saisanak; apparently an improved variety of *Malus baccata* or perhaps a hybrid; is sold locally dried as a sweetmeat and for compote and preserve material. To be used for the same purposes as the preceding." (Meyer.)

31691. SORBUS sp.

From near Santai, Mongolia.

"(No. 1622a, April 23, 1911.) A rowan tree found on the north slopes of a semiarid mountain, occurring at altitudes between 8,000 and 9,000 feet; is more or less shrubby in growth. Apparently very resistant to cold and adverse conditions; recommended therefore as an ornamental garden and park shrub for the most northern sections of the United States." (Meyer.)

31692. ROSA sp.**Rose.**

From near Bogh-dalak, Mongolia.

"(No. 1623a, April 24, 1911.) A small growing rose, occurring on sunburned, dry, rocky hills at altitudes of between 6,000 and 7,000 feet. Of value possibly in hybridization work to create hardy, drought-resistant strains of yellow-flowered roses." (Meyer.)

31688 to 31697—Continued.

31693. *ROSA* sp.

Rose.

From near Ghapsegai, Mongolia.

"(No. 1624a, April 26, 1911.) A shrubby rose found in dry, stony places at an altitude of 3,700 feet. May be yellow flowered; if so, the same remarks apply to it as made on the preceding number." (*Meyer*.)

31694. *ROSA* sp.

Rose.

From near Ghapsegai, Mongolia.

"(No. 1625a, April 27, 1911.) A wild rose of rather tall, bushy growth, covered with numerous spines, which are very white, color of flowers apparently rose. Of value possibly as a stock in dry, cold regions and as a factor in hybridization work." (*Meyer*.)

31695. *ROSA PERSICA* Michx.

Rose.

From near Ghapsegai, Mongolia, Russian territory.

"(No. 1626a, April 27, 1911.) A very rare and curious rose having small, yellow flowers and undivided, glaucous foliage; looks not unlike a barberry; grows to a height of from 1 to 3 feet. Occurs on dry clayey ridges and on alkaline loess plains between other vegetation. Of botanical interest only." (*Meyer*.)

31696. *SATUREJA* sp.

From near Barlik, Mongolia.

"(No. 1627a, May 1, 1911.) A labiate closely allied to thyme, having very pleasantly flavored foliage that can be advantageously used in soups, with meats, pickles, etc. Occurs on dry, rocky ridges and between stony débris. Especially suitable for the drier sections of the United States as a savory garden herb." (*Meyer*.)

31697. *RAPHANUS SATIVUS* L.

Radish.

From Chugutchak, Mongolia.

"(No. 1628a, May 16, 1911.) A medium-large variety of Chinese winter radish, called *Ching loba*. An excellent winter vegetable, which is eaten alike by Russians, Tartars, Sarts, Kalmucks, and Chinese, although introduced and grown by the last-named only in these parts of the world.

"The Chinese way of serving is to slice them in very thin strips, to sprinkle some soy-bean sauce or old vinegar over them, and to eat them as an appetizer. The Russian way, however, is to cut them in square strips, to sprinkle salt over them and a liberal quantity of vinegar, and to serve them as a salad with the regular meal.

"The plants like a well-drained yet rich soil and do not object to a certain amount of alkali. They require water and must be irrigated in times of drought, as otherwise they remain stunted and acquire a pungent taste. They are sown out in the latter part of July or early August, three to four seeds per hill and 1 to 1½ feet apart in all directions. Later on the plants are thinned out, so that only one is left, like beet roots, for instance.

"They stand light frosts, but must be harvested before the heavy frosts begin. They are pulled out by a twist of the hand and are left to dry out for some hours on the field; then the leaves are torn off and the roots are stored in dug-out cellars, much like potatoes or sugar beets. A few of the best are saved and planted out as soon as the danger of frosts is passed.

"These winter radishes deserve to become better known in the United States. They are of easy culture, attractive appearance, and possess a refreshing taste, while their appetizing and stomach-strengthening properties are so astonishing

31688 to 31697—Continued**31697—Continued.**

that the Chinese say that a man selling sliced *Ching lobas* near a boarding house ruins the boarding-house keeper. People doing much manual labor especially seem to be benefited by the use of them.

"As these roots stand long transportation very well, they will be useful in supplying mining camps and sailors with the necessary fresh vegetables. From the nature of the plants they will thrive especially well in the western United States. Seeds formerly sent under Nos. 17932, 17935 to 17937, 21623, 23968, and 23969." (*Meyer.*)

31698. MELILOTUS ALBA Desr.**Sweet clover.**

From Nice, France. Presented by Dr. A. Robertson Proschowsky. Received August 22, 1911.

"This clover grows 2 meters [6½ ft.] or more high. It has small white flowers and tiny reniform fruits. The general aspect is much like *Medicago sativa*, but the flowers are white and much smaller, fruits quite different. It is perennial, grows on the very worst soil, consisting of gravel, and looks quite fresh and green amidst its withered surroundings (no rain for last seven months). It seems to me that this might prove of interest to the specialists looking for forage plants for arid regions." (*Proschowsky.*)

31699 to 31701.

From China. Presented by Mr. N. Gist Gee, Soochow University, Soochow, China. Received July 31, 1911.

31699. LITCHI CHINENSIS Sonner.**Lychee.**

See Nos. 10670 to 10673, 14888, and 16237 to 16243 for descriptions.
Seeds.

31700. ERIOBOTRYA JAPONICA (Thunb.) Lindl.**Loquat.**

"*Bilo.*"

Seeds.

31701. ZINZIBER OFFICINALE Rosc.**Ginger.**

Roots.

31702. SOLANUM NIGRUM L.**Nightshade.**

From Nice, France. Presented by Dr. A. Robertson Proschowsky. Received August 16, 1911.

Variety *miniatura*.

31703. MEDICAGO FALCATA L. (?)

From Gilgit, Kashmir, British India. Presented by Mr. F. Booth Tucker, Salvation Army, Simla, British India. Received August 8, 1911.

31704 to 31707.

From Manila, Philippine Islands. Presented by Mr. P. J. Wester, horticulturist, Bureau of Agriculture. Received August 21, 1911.

Seeds of the following; quoted notes by Mr. Wester:

31704. TRICHOSANTHES QUINQUANGULATA A. Gray.

"A cucurbitaceous vine of vigorous growth indigenous to the Philippines. The fruit is globose and somewhat larger than an apple, the surface being a brilliant red. As the fruit keeps for many weeks after maturity, retaining its color, I believe that it might be used to great advantage for decorative purposes."

31704 to 31707—Continued.**31705. TRICHOSANTHES sp.**

"This species grows on a vine similar to the preceding, but the fruit is smaller and straw colored."

31706. (Undetermined.)

"An herbaceous, ornamental shrub with large leaves and vermilion-colored flowers produced in a terminal panicle, the bright-colored calyces being persistent for several weeks after the corollas have dropped."

31707. TERMINALIA EDULIS Blanco.

"A large forest tree with an open head, producing an edible, subacid fruit about the size of a small plum. If, as is probable, the tree succeeds in south Florida, it will be a valuable addition to your ornamental shade trees there and the fruit can probably be utilized in making jelly and other preserves."

31708. PRUNUS TRIFLORA Roxb.**Plum.**

From China. Presented by Mr. N. Gist Gee, Soochow University, Soochow, China. Received August 22, 1911.

"These seeds were obtained from fruits about an inch in diameter and blood red and were rather full of fibers." (*Gist Gee.*)

31709 to 31714.

From Ceylon. Presented by Mrs. Charles B. Bigelow, Boston, Mass., through Prof. C. S. Sargent, Arnold Arboretum, Jamaica Plain, Mass. Received August 3, 1911.

Seeds of the following:

31709. FERONIA ELEPHANTUM Correa.**Wood-apple.**

See No. 25888 for description.

31710. ANNONA MURICATA L.**Soursop.**

See No. 18737 for previous introduction.

Distribution.—Native and cultivated in tropical America, and introduced into other tropical countries.

31711. ANNONA CHERIMOLA Miller.**Cherimoya.****31712. ANNONA SQUAMOSA L.****Sweetsop.****31713. CHRYSOPHYLLUM CAINITO L.****Star-apple.**

See No. 27572 for description.

31714. CARICA PAPAYA L.**Papaya.****31715 to 31719.**

From Philippine Islands. Received through Mr. C. V. Piper, of the Bureau of Plant Industry, August 9, 1911.

Seeds of the following; quoted notes by Mr. Piper:

31715. SYNTERISMA CILIARIS (Retz.) Schrad.**Crab-grass.**

"From Lamao, June, 1911. A larger species than our common American crab-grass."

31716. DOLICHOS LABLAB L.**Bonavist bean.**

"Cultivated for a vegetable. Native name *Batao*. Grown at Lamao Experiment Station."

31717. ERIOCHLOA RAMOSA (Retz.) Kuntze.

"From Manila, June, 1911."

31715 to 31719—Continued.**31718. PHASEOLUS sp.**

"From Manila, June, 1911. Distributed by Mr. Merrill of the Manila Experiment Station as *Phaseolus calcaratus*, which it resembles in so far as it has yellow flowers and spurred wings, but the pods and seeds are very different."

31719. URARIA LAGOPODIODES (L.) Desv.

"A perennial legume with spreading stems 1 to 2 feet long. Readily eaten by cattle and producing abundant seed."

Distribution.—Southeastern Asia from India to China and through the Malay Archipelago and Polynesia to Australia.

31720. NORMANBYA MUELLERI Becc.**Palm.**

From Manila, Philippine Islands. Received through Mr. C. V. Piper, of the Bureau of Plant Industry, August 9, 1911.

"*Bonga de China*. A palm cultivated throughout the Philippine Islands, but its origin is unknown. It much resembles the betel-nut palm but has glaucous leaves and smaller, bright-crimson fruits about an inch long." (*Piper*.)

Distribution.—A palm found in the valley of the Daintree River in the province of Queensland, Australia, and cultivated in the Philippines.

31721 to 31723. CUOUMIS MELO L.**Muskmelon.**

From Comendador, Dominican Republic. Presented by Mr. M. E. Beall. Received August 24, 1911.

Seeds of the following; quoted notes by Mr. Beall:

31721. "This melon measured 31 centimeters [1 ft.] from stem to blossom end and 46 centimeters [14 in.] around the middle. Flesh green, firm but tender, of delicious flavor. I never tasted a better one. It does not need to be improved, and if it produces in the United States, the Rocky Ford will have to take a back seat."

31722. "This melon weighed 15 pounds, measured 23.6 inches from stem to blossom end, and 23.2 inches around the middle. Flesh thick, salmon colored, of good flavor. I am told that there are larger ones of this variety, but I have not seen them."

31723. "Small muskmelon or canteloupe, a little larger than a Rocky Ford. Skin not very firm, flesh greenish, not particularly fine flavored. Might be of value for hybridizing work."

31725. PISTACIA INTEGERRIMA Stewart.**Zebra wood.**

From Lahore, India. Procured by Mr. R. S. Woglum, of the Bureau of Entomology, United States Department of Agriculture, from Mr. W. R. Mustoe, Superintendent of the Botanical Gardens. Received August 24, 1911.

"These seeds were taken from a splendid specimen of a tree in the Agri-Horticultural Gardens." (*Woglum*.)

See No. 18637 for description.

Distribution.—On the mountain slopes in the northwestern part of India at an elevation of 1,200 to 8,000 feet; cultivated in the plains.

31726. CITRUS AURANTIUM SINENSIS L.**Orange.**

From Bahia, Brazil. Presented by Mr. Southard P. Warner, American consul. Received August 25, 1911.

Bahia navel. See Nos. 24311 and 30201 for previous introductions.

31727. VOANDZEIA SUBTERRANEA (L.) Thouars. Woandsu.

From Portuguese East Africa. Presented by Mr. R. H. B. Dickinson, Department of Agriculture, Salisbury, Southern Rhodesia. Received August 14, 1911.

See No. 23453 for description.

31728 to 31735.

From China. Received through Mr. C. V. Piper, of the Bureau of Plant Industry, August 21, 1911.

Seeds of the following; quoted notes by Mr. Piper:

31728. PHASEOLUS CALCARATUS Roxb.

"From the market in Canton, said to be grown in the neighborhood."

31729. DOLICHOS LABLAB L.

Bonavist bean.

"From the market in Canton, said to be grown about Tientsin."

31730 and 31731. CLAUCENA LANSIUM (Lour.) Skeels.

Wampee.

"Both of these varieties were purchased in the market at Canton, where they occur in great abundance at this season (July). The former is an acid variety, the fruit as large as a muscat grape, but tapering to the apex. The latter is sweet, a little smaller, and perfectly ellipsoid. Both are greenish yellow in color and normally contain five (?) seeds, but the sour one rarely has more than one seed. The fruit is only of mediocre quality, but the Chinese eat large quantities of it."

See Nos. 25546 and 27954 for previous introductions.

31732. MANGIFERA INDICA L.

Mango.

"*Hamow*. From Canton. Said to be the best mango grown in South China. Fruit a rich apricot color, without blemish, about 2½ inches long, 2 inches broad, and 1½ inches thick; snout short, blunt; flesh apricot color, watery, and with little flavor, not at all turpentine; skin thin, not peeling easily; not much fiber; stone large. A very attractive fruit, but in quality not to be compared with Manila mangos."

31733. PRUNUS SIMONII Cart.

"Common in the markets of Canton and Hongkong. Fruit subglobose, greenish; flesh red. Very good when stewed."

31734. PRUNUS TRIFLORA Roxb.

"Like the preceeding but smaller and quite red on the surface."

31735. RUBUS sp.

"An ornamental variety with grapelike leaves, rusty tomentose beneath. Fruit red, small."

31736. CAJUPUTI LEUCADENDRA (Stickman) Rusby. Cajuput tree.

See No. 30761 for explanation of the necessity for using the generic name Cajuputi.

From Sydney, New South Wales, Australia. Presented by Mr. J. H. Maiden, director, Botanic Gardens. Received August 29, 1911.

"This is a myrtaceous tree closely related to the eucalyptus. Present indications are that the tree will prove very valuable for avenue planting and windbreaks in southern Florida. It is a rapid grower and adapts itself readily to different conditions of soil and surroundings. It is able to withstand the effects of salt spray and is not

hurt by occasional tidal overflows. Trees set out as small seedlings in 1909 at Coconut Grove, Fla., have bloomed and produced this season (1911) after reaching a height of about 15 to 20 feet." (*H. F. Schultz.*)

Distribution.—From India southeastward through the Malay Archipelago to Australia.

31737. ZIZIPHUS JUJUBA Miller.

Jujube.

From Chugutchak, Mongolia. Received through Mr. Frank N. Meyer, agricultural explorer, August 18, 1911.

"(May 4, 1911.) Very large Chinese jujubes, several varieties mixed. Said to come from Honan Province, north-central China." (*Meyer.*)

31738. ACANTHOSICYOS HORRIDA Welw.

Narras.

From Windhoek, German Southwest Africa. Presented by the German Government. Received July 26, 1911.

See No. 31401 for description.

31739. CASTILLA sp. (?)

Central American rubber.

From San Jose, Costa Rica. Presented by Mr. Carlos Wercklé, Museo Nacional, September 1, 1911.

Seeds.

31740. CITRUS AURANTIUM SINENSIS L.

Orange.

From Avery Island, La. Presented by Mr. E. A. McIlhenny, at the request of Mr. C. W. Ward. Received September 5, 1911.

"Bud wood from a seminael orange. This orange is the size of the Washington Navel, has a very thin skin and two or three seeds, but is decidedly similar in shape and outward appearance to the Washington Navel." (*McIlhenny.*)

31741 to 31747.

From Chile. Presented by Mr. Andrew Kerr, American consular agent, Coquimbo, Chile. Received January 5, 1911. Numbered September 5, 1911.

Plants of the following:

31741. EUGENIA LUMA (Mol.) Berg.

"*Meli.*"

Distribution.—A tree found in Chile from the vicinity of Concepcion southward to the island of Chiloe.

31742. EUGENIA sp.

"*Arrayan.*"

31743. CALDCLUVIA PANICULATA (Cav.) Don.

"*Tiaca.*"

31744. PHILESIA MAGELLANICA Gmelin.

"*Coi Copihue.*"

Distribution.—The coast of South America from Chile to the Straits of Magellan.

31745 to 31747. (Undetermined.)

31745. "Boqui."

31747. "Tepú."

31746. "Chin-Chin."

31748. EUCLEA RACEMOSA Murray.

From Cape Town, South Africa. Presented by Mr. T. F. Dreyer, assistant entomologist, Department of Agriculture, Cape of Good Hope. Received September 5, 1911.

See No. 9620 for description.

Distribution.—The southern and western districts of South Africa.

31751. ANACARDIUM OCCIDENTALE L.**Cashew.**

From Inhamban, Portuguese East Africa. Presented by Mr. P. W. Keys, superintendent, Limpopo District Methodist Episcopal Mission. Received September 6, 1911.

31753 and 31754.

From Kew, England. Procured from the Herbaceous Garden at Kew by Prof. William R. Lazenby, Ohio State University, Columbus, Ohio. Received August 31, 1911.

Seeds of the following; quoted notes by Prof. Lazenby:

31753. PHYSALIS IXOCARPA Brot.

"This is the most promising *Physalis* I have seen."

31754. SOLANUM NIGRUM L.**Nightshade.**

"Variety *douglasii*. This looks much like what we have grown in Ohio under the name 'garden huckleberry.'"

31755. PRUNUS ARMENIACA L.**Apricot.**

From Merv, Russian Turkestan. Presented by Mr. W. W. Mackie, director, Yaqui Valley Experiment Station, Esperanza, Sonora, Mexico, who secured them in May, 1911. Received September 7, 1911.

Arak.

Seeds.

31758. COFFEA DEWEVREI Wildem. and Dur.**Coffee.**

From the Kongo. Presented by the Minister for the Colonies, Brussels, Belgium, at the request of Mr. Émile de Wildeman, conservator, Botanical Gardens, Brussels. Received September 8, 1911.

Distribution.—A tall tree found in the Kongo region of western Africa.

31759. MANGIFERA INDICA L.**Mango.**

From Sibpur, Calcutta, India. Presented by Maj. A. T. Gage, superintendent, Royal Botanic Garden. Received September 8, 1911.

Baramasee (?).

31760. MANGIFERA INDICA L.**Mango.**

From St. George, Grenada, British West Indies. Purchased from Mr. Gilbert Auchinleck, Superintendent of Agriculture, Grenada Agricultural Department. Received September 11, 1911.

"Grenada Ceylon No. 1."

Plant.

31761. BAMBOS ARUNDINACEA Retz. Bamboo.

From Lansdowne, United Provinces, India. Procured from the Lansdowne Forest Division Office by Mr. W. R. Mustoe, superintendent, Botanic Gardens, Lahore, India, and presented by him through Mr. R. S. Woglum, of the Bureau of Entomology, United States Department of Agriculture. Received August 24, 1911.

Introduced for the work of this office in the trial of suitable bamboos for cultivation as an important timber supply in the Southern States.

31763. MANGIFERA INDICA L. Mango.

From Darbhanga, India. Presented by Maj. A. T. Gage, superintendent, Royal Botanic Garden, Sibpur, Calcutta, India. Received August 23, 1911. Numbered September 13, 1911.

Baboony.

Plants.

31764 and 31765. HORDEUM spp. Barley.

From the hills in the Simla district of the Punjab, India. Presented by Mr. Bernard Coventry, Officiating Inspector General of Agriculture in India, Pusa. Received September 13, 1911.

Seeds of the following; quoted notes received with seed:

31764. HORDEUM sp. Awnless barley.

"*Kharsila.*"

31765. HORDEUM sp. Hooded barley.

"*Haua.*"

"The origin of these varieties is not known. The crop is used both as human and animal food. There are no special methods of cultivation of this crop, and the usual methods obtaining in the hills for the cultivation of winter cereals is followed. Briefly, these consist in thoroughly preparing the soil in the monsoon by repeated ploughings and harrowings. A light dressing of cattle manure or house sweepings, if available, is given in August and the seed is sown broadcast in October. Very little care is required after sowing, except irrigation if possible, and the crop matures in five and one-half to six months. The average outturn of barley is 1,200 pounds per acre."

31766. LEUCAENA GLAUCA (L.) Benth.

From Brazil. Presented by Mr. Clinton D. Smith, Escola Agricola Practica "Luiz de Queiro," Piracicaba, Brazil. Received April 5, 1911. Numbered September 15, 1911.

See Nos. 755, 8998, and 23340 for previous introductions.

31767. INTSIA sp.

From Lawang, Java. Presented by Mr. M. Buysman. Received August 18, 1910. Numbered September 15, 1911.

Seeds.

31768. DAHLIA sp.

From Brazil. Presented by Mr. E. G. Swain, Diamantino, Brazil. Received July 24, 1911. Numbered September 15, 1911.

"A mixed-colored dahlia, red and white flowers, imported from Portugal." (*Swain.*)

31769 and 31770.

From China. Presented by Mr. T. M. Wilkinson, Foochow, China. Received July 5, 1911. Numbered September 15, 1911.

Seeds of the following; quoted notes by Mr. Wilkinson:

31769. QUERCUS sp.

Oak.

31770. ERIOBOTRYA JAPONICA (Thunb.) Lindl.

Loquat.

"*Beba*. This fruit tree begins to bloom the last of November and during the month of December. It has been in fruit for the last three weeks (May 16, 1911). The leaf is about 6 inches long and an inch or an inch and a half wide, has numerous ribs, and is dark green in color. The tree is inclined to grow straight and tall, the branches coming out of the main trunk at regular intervals and three, five, or seven of them at a time."

31771. (Undetermined.)

From Costa Rica. Presented by Mr. Carlos Wercklé, San Jose, Costa Rica. Received August, 1911. Numbered September 15, 1911.

Seeds.

31772. BROMELIA sp.

Bromelia.

From Chile. Presented by Mr. José D. Husbands, Limavida, via Molina, Chile. Received August 14, 1911. Numbered September 15, 1911.

"From Coquimbo. This looks like a new class of *chupones* (Bromelia). These plants will probably be found to have some ornamental or economic value." (*Husbands*.)

Seeds.

31773. GEONOMA sp.

Palm.

From San Jose, Costa Rica. Presented by Mr. Carlos Wercklé, Museo Nacional. Received September 14, 1911.

This is probably the same species as No. 31930, but may be distinct.

Seeds.

31774. SOLANUM NIGRUM L.

Nightshade.

From Kew, England. Presented by Dr. David Prain, director, Royal Botanic Gardens. Received September 14, 1911.

Introduced for breeding experiments.

Seeds.

31775. CITRULLUS VULGARIS Schrad.

Watermelon.

From Changchu, near Soochow, China. Presented by Mr. N. Gist Gee, Soochow, China. Received September 14, 1911.

"*Mo Ling Quo* (horse-bell melon). Best grown at Changchu." (*Gee*.)

31776. CARYOPHYLLUS AROMATICUS L.

Clove.

From Port of Spain, Trinidad, British West Indies. Presented by the director, Botanical Department, Department of Agriculture. Received September 19, 1911.

See No. 27680 for description.

Seeds.

31779. POPULUS HETEROPHYLLA L.**Poplar.**

From Worcester County, Md. Collected 5 miles northeast of Pocomoke, by Mr. Ivar Tidestrom, of this Department, September 18, 1911. Received September 20, 1911.

"Native of eastern North America. Grows to a height of 30 feet or more, with a straight trunk." (*Tidestrom.*)

31780 to 31832.

Received through Mr. Frank N. Meyer, agricultural explorer, September 11, 1911.

Seeds of the following:

31780. TRITICUM AESTIVUM L.**Wheat.**

From the Oasis of Khotan, Chinese Turkestan.

"(No. 1471a, November 23, 1910.) A very fine variety of red winter wheat called *Kizil boogdai*.

"The wheats of Khotan are celebrated in Chinese Turkestan for their excellence and for the fine taste they impart to the bread baked from them. All these wheats are raised under irrigation and very often on land that is quite saline." (*Meyer.*)

31781. TRITICUM AESTIVUM L.**Wheat.**

From the Oasis of Khotan, Chinese Turkestan.

"(No. 1472a, November 24, 1910.) A good, hard, white, winter wheat called *Ak mecca boogdai*. Said to have been introduced from Mecca." (*Meyer.*)

31782. TRITICUM AESTIVUM L.**Wheat.**

From the Oasis of Khotan, Chinese Turkestan.

"(No. 1473a, November 23, 1910.) A very fine quality of white, summer wheat called *Ak-boogdai*." (*Meyer.*)

31783. TRITICUM AESTIVUM L.**Wheat.**

From the Oasis of Khotan, Chinese Turkestan.

"(No. 1474a, November 23, 1910.) A large variety of red, summer wheat called *Kizil boogdai*." (*Meyer.*)

31784. TRITICUM AESTIVUM L.**Wheat.**

From the Oasis of Khotan, Chinese Turkestan.

"(No. 1475a, November 24, 1910.) A red, summer wheat called *Kizil boogdai*." (*Meyer.*)

31785. TRITICUM AESTIVUM L.**Wheat.**

From San Kia, Chinese Turkestan.

"(No. 1476a, November 17, 1910.) A fine quality of summer wheat grown on light, sandy soil." (*Meyer.*)

31786. TRITICUM AESTIVUM L.**Wheat.**

From Pi-yalma, Chinese Turkestan.

"(No. 1477a, November 18, 1910.) A fine quality of summer wheat grown like No. 1476a (S. P. I. No. 31785)." (*Meyer.*)

31787. TRITICUM AESTIVUM L.**Wheat.**

From Khanaka, Oasis of Sandju, Chinese Turkestan.

"(No. 1478a, December 4, 1910.) A good, white, summer wheat called *Andishan boogdai*. Said to have come originally from Andishan." (*Meyer.*)

31780 to 31832—Continued.

31788. *TRITICUM AESTIVUM* L. Wheat.

From Burya Lyang, Chinese Turkestan.

"(No. 1479a, December 8, 1910.) A red, summer wheat called *Kizil boog-dai*." (Meyer.)

31789. *TRITICUM AESTIVUM* L. Wheat.

From Karawag, Chinese Turkestan.

"(No. 1480a, December 10, 1910.) A rare local variety of white, summer wheat having very large grains, called *Ak-boogdai*." (Meyer.)

31790. *TRITICUM AESTIVUM* L. Wheat.

From Karghalik, Chinese Turkestan.

"(No. 1481a, December 12, 1910.) A local variety of red, hard wheat called *Kizil boogdai*." (Meyer.)

31791. *TRITICUM AESTIVUM* L. Wheat.

From Kashgar, Chinese Turkestan.

"(No. 1482a, October 23, 1910.) A good quality of Kashgar wheat called *Kizil boogdai*."

"All of these wheats, having been raised for centuries in an arid climate under irrigation, may thrive better in the hot southwestern parts of the United States than anywhere else; still they might also be given a trial in cooler arid and semiarid regions, but should not be tested in the humid eastern sections." (Meyer.)

31792. *HORDEUM VULGARE* L. Barley.

From Nusi, Chinese Turkestan.

"(No. 1483a, November 28, 1910.) A winter barley called *Chilgà arpa*. Able to withstand considerable drought and alkali." (Meyer.)

31793. *HORDEUM* sp. Hull-less barley.

From Khanaka, Oasis of Sandju, Chinese Turkestan.

"(No. 1484a, December 4, 1910.) Summer barley, grown on rather sandy land at an elevation of over 6,000 feet above sea level." (Meyer.)

31794. *HORDEUM VULGARE HIMALAYENSE* Rittig. Hull-less barley.

From Pushki, Chinese Turkestan.

"(No. 1485a, December 1, 1910.) A blue, hull-less, summer barley called *Kok-arpa*. Grown in a dry, cool region under irrigation." (Meyer.)

31795. *HORDEUM* sp. Hull-less barley.

From Pudskya, Chinese Turkestan.

"(No. 1486a, November 29, 1910.) A very fine variety of white, hull-less, summer barley called *Ak-arpa*. The flour made from this is used mixed with wheat flour for bread making. It is generally sown very early, as soon as the frost leaves the ground." (Meyer.)

31796. *HORDEUM* sp. Hull-less barley.

From Pustan Terek, Chinese Turkestan.

"(No. 1487a, December 29, 1910.) An excellent large variety of hull-less summer barley, grown by the Kirghiz in mountain valleys at altitudes from 6,000 to 7,000 feet. The flour of this barley mixed with wheat flour gives the little loaves baked from it remarkable nourishing and sustaining qualities. To be tested in the rocky and intermountain regions of the United States." (Meyer.)

31780 to 31832—Continued.

31797. *CICER ARIETINUM* L.

Chick-pea.

From Khokan, Russian Turkestan.

"(No. 1489a, September 28, 1910.) A small variety of chick-pea called *Oh-nagh*, apparently one of the more primitive strains of garbanzos. Grown on the rather alkaline lands around Khokan. Eaten boiled in soups and meat stews." (Meyer.)

31798. *CICER ARIETINUM* L.

Chick-pea.

From Khokan, Russian Turkestan.

"(No. 1490a, September 28, 1910.) A brown variety of chick-pea called *Kizil nagh*. Apparently a very primitive strain. Eaten like the preceding number, but retails at only half the price. May be tested as a forage crop on the alkaline lands of the warmer sections of the United States." (Meyer.)

31799. *VIGNA SINENSIS* (Torner) Savi.

Cowpea.

From Khotan, Chinese Turkestan.

"(No. 1491a, November 26, 1910.) A rather small variety of cowpea grown for human food. To be tested under irrigation in the desert regions of the United States." (Meyer.)

31800. *VIGNA SINENSIS* (Torner) Savi.

Cowpea.

From Karghalik, Chinese Turkestan.

"(No. 1492a, December 12, 1910.) A yellowish variety of cowpea called *Shou to*. To be tested like No. 1491a (S. P. I. No. 31799)." (Meyer.)

31801. *VIGNA SINENSIS* (Torner) Savi.

Cowpea.

From Yarkand, Chinese Turkestan.

"(No. 1493a, December 18, 1910.) A rare local variety of cowpea, having brown mottled seeds. Eaten stewed with meats. To be tested like No. 1491a (S. P. I. No. 31799)." (Meyer.)

31802. *GLYCINE HISPIDA* (Moench) Maxim.

Soy bean.

From Karghalik, Chinese Turkestan.

"(No. 1494a, December 12, 1910.) A large, green variety of soy bean called *Ching tou*, used when slightly salted and roasted as an appetizer before meals. To be tested like No. 1491a (S. P. I. No. 31799)." (Meyer.)

31803. *GLYCINE HISPIDA* (Moench) Maxim.

Soy bean.

From Kashgar, Chinese Turkestan.

"(No. 1495a, October 23, 1910.) A black soy bean, used like No. 1494a (S. P. I. No. 31802), and also used to make bean curd. To be tried like No. 1491a (S. P. I. No. 31799)." (Meyer.)

31804. *GLYCINE HISPIDA* (Moench) Maxim.

Soy bean.

From Karghalik, Chinese Turkestan.

"(No. 1496a, December 12, 1910.) A large, black soy bean called *Ghae tou*. Used like No. 1494a (S. P. I. No. 31802)." (Meyer.)

31805. *PISUM SATIVUM* L.

Pea.

From San-Kia, Chinese Turkestan.

"(No. 1497a, November 17, 1910.) A small green pea called *Puchok*. Sown early on sandy lands, mostly between wheat. They are eaten boiled in soups and also ground and baked in bread. To be tested as a summer forage crop in the intermountain and Rocky Mountain regions or as a winter crop in moist, mild-winter sections of the United States." (Meyer.)

31780 to 31832—Continued.

31806. *PISUM ARVENSE* L.

Field pea.

From Khotan, Chinese Turkestan.

"(No. 1498a, November 26, 1910.) Various varieties of peas mixed. Grown as an early crop on light, sandy, alkaline lands. See remarks under the preceding number." (*Meyer.*)

31807. *PISUM ARVENSE* L.

Field pea.

From Pushki, Chinese Turkestan.

"(No. 1500a, December 1, 1910.) A small speckled pea called *Puchok*. Grown between wheat on sandy lands. See also remarks under No. 1497a (S. P. I. No. 31805)." (*Meyer.*)

31808. *PISUM ARVENSE* L.

Field pea.

From Khanaka, Oasis of Sandju, Chinese Turkestan.

"(No. 1501a, December 4, 1910.) A small speckled pea sown on rather light soils between barley. See also remarks under No. 1497a (S. P. I. No. 31805)." (*Meyer.*)

31809. *PISUM SATIVUM* L.

Pea.

From Pudskiya, Chinese Turkestan.

"(No. 1502a, November 29, 1910.) A pea called *Puchok*, sown on rather sandy and alkaline soils between wheat. See remarks under No. 1497a (S. P. I. No. 31805)." (*Meyer.*)

31810. *LATHYRUS SATIVUS* L.

From Pudskiya, Chinese Turkestan.

"(No. 1503a, November 29, 1910.) A legume called *Kara puchok*, meaning black pea, sown on light, alkaline soils between wheat. The seeds are eaten as food, boiled in soups or ground and mixed with wheat flour and baked into little loaves. I asked especially about the supposed poisonous effects of this legume, but the natives said they never heard of it. To be tested like No. 1497a (S. P. I. No. 31805)." (*Meyer.*)

31811. *MEDICAGO SATIVA* L.

Alfalfa.

From Khotan, Chinese Turkestan.

"(No. 1504a, November 24, 1910.) A variety of alfalfa called *Chilga beda*, meaning fibery lucern. This variety seems to need less irrigation than the following number. A tall grower; stems erect, slightly woody; leaves rather small; good for hay." (*Meyer.*)

31812. *MEDICAGO SATIVA* L.

Alfalfa.

From Khotan, Chinese Turkestan.

"(No. 1505a, November 24, 1910.) A variety of alfalfa called *Kara beda*, meaning black lucern. Leaves large, dark green; stems succulent, not very high growing. Not as good for hay as the preceding number; however, it supplies green fodder until frost, while the *Chilga* variety stops growing at the end of summer. It is not able to stand as severe cold as the *Chilga*." (*Meyer.*)

31813. *MEDICAGO SATIVA* L.

Alfalfa.

From Kashgar, Chinese Turkestan.

"(No. 1506a, January 14, 1911.) An alfalfa called *Kara beda*. In Kashgar this is considered the better of two varieties. It is apparently the same as the *Chilga beda* from Khotan." (*Meyer.*)

31780 to 31832—Continued.

31814. *MEDICAGO SATIVA* L.

Alfalfa.

From Kashgar, Chinese Turkestan.

"(No. 1507a, January 14, 1911.) An alfalfa called *No beda*, meaning hollow lucern, on account of the stems being succulent and hollow. Seems to be the same as the *Kara* from Khotan.

"As vegetable culture stands on a very low level in Chinese Turkestan and as early vegetables do not exist, both foreign residents and natives eat the young alfalfa sprouts prepared like spinach, which vegetable they are said to resemble very much in taste and looks." (Meyer.)

31815. *MEDICAGO SATIVA* L.

Alfalfa.

From Khanaka, Oasis of Sandju, Chinese Turkestan, 6,000 feet altitude.

"(No. 1508a, December 4, 1910.) An alfalfa called *Chilga beda*, apparently the same as No. 1504a (S. P. I. No. 31811). This variety of alfalfa ripens seed here in small quantities only, while the *Kara beda*, No. 1505a (S. P. I. No. 31812), never ripens at all and seeds have to be imported from Guma, situated at 4,000 feet elevation above sea level. This number therefore may show unusually hardy qualities and ought to be tested in a dry, cold region." (Meyer.)

31816. *CANNABIS SATIVA* L.

Hemp.

From Khanaka, Oasis of Sandju, Chinese Turkestan.

"(No. 1511a, December 4, 1910.) A small-seeded variety of hemp called *Kandivi*. The oil expressed from the seeds is used for culinary and illuminating purposes. The fiber is not generally utilized, except for some very inferior rope that here and there is made from it. From the young tops, however, the hashish is made, and many are the victims addicted to the smoking of this narcotic." (Meyer.)

31817. *LINUM USITATISSIMUM* L.

Flax.

From Khanaka, Oasis of Sandju, Chinese Turkestan.

"(No. 1512a, December 4, 1911.) Native name *Sigger*. Flax is extensively cultivated in both Russian and Chinese Turkestan, not for its fiber, however, but solely for the oil the seeds yield. The oil is much used in the native cooking, while the Russian settlers in central Asia have also become used to it. This linseed oil when fresh is a very palatable oil and can be used with excellent results in the frying of fish, doughnuts, pancakes, etc.

"Flax for its oil-yielding capacities seems to be very promising as a crop for those sections of the United States where the summers are short and dry, especially the mountainous western part and in the outlying districts where settlers have to grow what they need as much as possible.

"Linseed oil is much easier digested than cottonseed oil and ought to be tested as human food." (Meyer.)

31818. *LINUM USITATISSIMUM* L.

Flax.

From Tashmalah, Chinese Turkestan.

"(No. 1513a, December 23, 1910.) Variety *semina lutea*. A variety with light-yellow seeds. Used for the same purpose as No. 1512a (S. P. I. No. 31817). Native name *Sigger*." (Meyer.)

31819. *ERUCA SATIVA* Hill.

Roquette.

From Khanaka, Oasis of Sandju, Chinese Turkestan.

"(No. 1514a, December 4, 1910.) Native name *Sa-un*. A variety of rape seed, the oil of which is used both for culinary and illuminating purposes. To be tested as a possible crop for the intermountain regions." (Meyer.)

31780 to 31832—Continued.

31820. *ERUCA SATIVA* Hilfl.

Roquette.

From Karawag, Chinese Turkestan.

"(No. 1515a, December 10, 1910.) A variety slightly different from No. 1514a (S. P. I. No. 31819); also comes from a warmer locality. Native name *Sa-un*. The same remarks as made under No. 1514a (S. P. I. No. 31819) apply also to this one." (*Meyer*.)

31821. *BRASSICA NAPUS* L.

Mustard.

From Khasan-dugra, Chinese Turkestan.

"(No. 1516a, December 7, 1910.) A mustard which is said to grow very tall. Likes a somewhat alkaline soil. An oil that is used to smear over bread in the baking process is expressed from the seeds. To be tested with care, as it may be of a weedy disposition." (*Meyer*.)

31822. *ELAEAGNUS ANGUSTIFOLIA* L.

Oleaster.

From Upal, Chinese Turkestan.

"(No. 1546a, December 31, 1910.) The oleaster is mostly seen as a tall shrub, but in good situations it grows sometimes to be a fair-sized tree. All things considered, it is perhaps the most useful tree in Chinese Turkestan. When well kept it supplies excellent hedges, almost impenetrable to man and beast. From the branches stuck in the ground in slanting and zigzag fashion, very good temporary fences can be made. As a windbreak it is unexcelled, keeping the drying desert winds off the cultivated lands of the oasis. As a sand binder it is of great value, checking blowing and encroaching desert sands to a great extent; also where washouts are experienced, its masses of fibrous roots retain the soil to a great extent.

"In many cases its wood constitutes the chief fuel supply, and to furnish this firewood the trees are pollarded every four to six years without suffering. The wood, when dry, possesses fine heating qualities and makes a good bed of live coals which lasts the whole night when covered up with ashes.

"The fruits of the wild form are too small and too astringent to be of any value to man, but some of the cultivated forms supply a sweetmeat to children. The dry cast-off leaves are a favorite food of sheep, goats, donkeys, and cattle. The flowers possess a remarkably sweet odor and seem to be rich in honey.

"Its highly ornamental qualities combined with drought and alkali resistant capacities put it in the first class as a desirable garden and park shrub or tree in the more arid parts of the United States. Its silvery-gray foliage resembles the olive very much, while in autumn the contrast between it and the multitude of generally orange-red small fruits is gloriously beautiful.

"The habit of this oleaster is extremely variable, the majority of the trees drooping gracefully when becoming old; some, however, assume quite rigid outlines. The size of the fruit also varies considerably, ranging from that of a pea up to an ordinary date. The berries vary from pure white on some trees to dark brownish red on others. Even in the leaves there is considerable variation in size, nuances of grayish green, and the relative quantity a tree may possess.

"The roots are sometimes a mass of nodules and, as the trees often grow quite luxuriantly even in pure sand, they seem to derive nutrition from these tubercles and, perhaps, even fertilize the soil to some extent. One notices, for instance, that crops, though close up to a row of oleaster trees, are not impoverished to any extent. For this reason the natives of central Asia seem to prefer this tree to any other sort of windbreak. The plants are able to grow in pure

31780 to 31832—Continued.

31822—Continued.

sand or in alkaline soils, and while they can exist with very little water they do not grow luxuriantly. They can not stand low, water-logged soils.

"Their propagation is easy; cuttings from the size of a lead pencil up to poles 6 feet long and 2 to 3 inches thick all strike roots easily, as long as the soil is moist enough to give them a chance. In those regions of the United States where the summers are very hot and dry and the winters are not too cold, where the soils are sandy or alkaline but where irrigation water is occasionally supplied, the oleaster deserves the highest consideration as a hedge plant, as a fence material, as a windbreak, as a sand binder, as a fuel supplier, and as a characteristic ornamental tree around the home." (*Meyer.*)

31823. *ORYZA SATIVA* L.

Rice.

From Yarkand, Chinese Turkestan.

"(No. 1571a, December 19, 1910.) A Chinese variety of glutinous rice called *Lo mi*. Originally introduced from eastern China, now sparingly grown around Yarkand. It is considered a very fine variety and almost twice as expensive as other rices.

"This and the following varieties of rices should be tested in the western sections of the United States. They are all grown in standing water and the soil in which they thrive is generally well charged with alkali. Rice is a rather expensive food in Chinese Turkestan on account of the scarcity of water, which could be employed for other crops, but the people as a whole are so fond of it that they are willing to make many sacrifices for it. Several local varieties have been developed during the long period of human occupation, and some of the best are being offered here." (*Meyer.*)

31824. *ORYZA SATIVA* L.

Rice.

From Yarkand, Chinese Turkestan.

"(No. 1572a, December 19, 1910.) A variety of rice called *Khotan Dowsera*. The grains become large and very white when boiled, and this variety is considered very good." (*Meyer.*)

31825. *ORYZA SATIVA* L.

Rice.

From Yarkand, Chinese Turkestan.

"(No. 1573a, December 19, 1910.) A variety of rice called *Ak-zu*; has red beards. Said to be very white and plump when boiled." (*Meyer.*)

31826. *ORYZA SATIVA* L.

Rice.

From Yarkand, Chinese Turkestan.

"(No. 1574a, December 14, 1910.) A variety of rice called *Kara Kültrick*; has black beards." (*Meyer.*)

31827. *ORYZA SATIVA* L.

Rice.

From Yarkand, Chinese Turkestan.

"(No. 1575a, December 19, 1910.) A variety of rice called *Yarkand Dowsera*; has white beards. It is considered the best variety locally, as it has about the same qualities as the *Khotan Dowsera* (No. 31824.)" (*Meyer.*)

31828. *ORYZA SATIVA* L.

Rice.

From Yarkand, Chinese Turkestan.

"(No. 1576a, December 19, 1910.) A variety of rice called *Sarich Kültrick*; has yellow beards, but white seeds." (*Meyer.*)

31780 to 31832—Continued.

31829. *ORYZA SATIVA* L.

Rice.

From Kashgar, Chinese Turkestan.

"(No. 1577a, January 27, 1911.) A variety of rice called *Ak-uruk*; has large, white grains." (*Meyer*.)

31830. *ORYZA SATIVA* L.

Rice.

From Kashgar, Chinese Turkestan.

"(No. 1578a, January 27, 1911.) A variety of rice called *Chilga*; of light milling qualities. Considered locally a marvel, as it ripens in 10 weeks after being sown. It is grown as a second crop after the winter wheat has been harvested." (*Meyer*.)

31831. *ORYZA SATIVA* L.

Rice.

From Kashgar, Chinese Turkestan.

"(No. 1579a, January 27, 1911.) A variety of rice called *Kara Kiltrick*. It has white beards and is very different from the same variety of Yarkand (No. 31826)." (*Meyer*.)

31832. *ORYZA SATIVA* L.

Rice.

From Kashgar, Chinese Turkestan.

"(No. 1580a, February 1, 1911.) A variety of rice called *Tum-uruk*. Considered to be a very good sort. Early ripener. White and reddish grains are said to exist intermixed in this variety." (*Meyer*.)

31835 to 31864.

From the Natal Botanic Gardens, Durban, Natal, South Africa. Presented by Dr. J. Medley Wood, director, Natal Botanic Gardens. Received July 15, 1911.

Seeds of the following:

31835. *ASPARAGUS FALCATUS* L.

Asparagus.

An ornamental flowering climber with creamy-white sweet-scented flowers in large panicles.

Distribution.—In the island of Ceylon, and in tropical and southern Africa, extending from Nubia and Upper Guinea southward to the Cape.

31836. *BAUHNIA PICTA* (H. B. K.) DC.

See No. 21783 for description.

31837. *BOSCIA UNDULATA* Thunb.

See No. 28719 for previous introduction.

31838. *BRUNSFELSIA AMERICANA* L.

See No. 28720 for previous introduction.

31839. *CALPURNIA AUREA* (Lam.) Benth.

See No. 28721 for previous introduction.

31840 and 31841. *CARISSA* spp.

Introduced in order to extend the cultivation of these important home-garden fruits for the Southern States.

31840. *CARISSA BISPINOSA* (L.) Desf.

Distribution.—Central southern Africa, extending from Rhodesia and the Mozambique district southward to the Cape.

31841. *CARISSA GRANDIFLORA* (Mey.) DC.

Amatungulu.

31835 to 31864—Continued.

31842. *CHRYSOPHYLLUM VIRIDIFOLIUM* Wood and Franks.

Distribution.—A tree found in the woods in the vicinity of Durban in Natal, Africa.

31843. *CRACCA GRANDIFLORA* (Ait.) Kuntze.

Distribution.—A leguminous shrub with red flowers found along the eastern coast of South Africa from Durban to Uitenhage.

31844. *CROTALARIA GRANTIANA* Harvey.

Distribution.—A small, slender, leguminous plant found in the vicinity of Durban in South Africa.

31845. *CRYPTOCARYA WOODII* Engler.

Distribution.—In the woods in the vicinity of Durban, South Africa.

31846. *DRACAENA RUMPHII* (Hook.) Regel.

See No. 28724 for previous introduction.

31847. *GLORIOSA SIMPLEX* L.

Distribution.—Tropical and South Africa, extending from Upper Guinea and the Nile land southward to the Cape.

31848. *INDIGOFERA* sp.

31849. *LITTONIA MODESTA* Hook. f.

Distribution.—A tuberous-rooted climbing vine belonging to the family Melanthiaceae, and growing in the Kalahari region and in the vicinity of Durban in South Africa.

31850. *MILLETTIA GRANDIS* (E. Meyer) Skeels.

(*Virgilia grandis* E. Meyer 1835, *Commentariorum de Plantis Africae Australioris*, vol. 1, p. 1.)

(*Millettia caffra* Benth. 1843, *Journal of Botany*, London, vol. 2, p. 99.)

This South African leguminous tree was first named *Virgilia grandis* by E. Meyer in 1835, and later was given the name *Millettia caffra* by Benth, who apparently did not know of the earlier name. In accordance with present rules of botanical nomenclature the earliest specific name, *grandis*, is here restored.

Millettia grandis is found on the rocky slopes of the mountains in the vicinity of Durban in South Africa.

31851. *MONDIA WHITEI* (Hook. f.) Skeels.

"It may be interesting to note that the fishermen at Fajao use as a line a fiber obtained from a climbing asclepiad (evidently *Chlorocodon whitei* [now *Mondia whitei*]) which is common in bushland throughout Unyoro. It has great strength and durability, a line about the size of an ordinary thread holding a fish from 4 to 6 pounds in weight. The roots of the same plant are eaten by the natives as a tonic, and are of a pleasant taste." (*Dawe, Economic Resources of Uganda*, p. 32.)

See No. 28730 for previous introduction.

31852. *MORAEA TRIDIODES* L.

See Nos. 13732, 28727, and 31253 for previous introductions.

31853. *OPHIOBOSTRYX VOLUBILIS* (Harvey) Skeels.

See No. 28729 for previous introduction.

31835 to 31864—Continued.

31854. *ORNITHOGALUM SAUNDERSIAE* Baker.

Distribution.—A white-flowered bulbous perennial growing in damp places among rocks at an elevation of 3,000 to 3,400 feet in the Kalahari region of South Africa.

31855. *ORNITHOGALUM THYRSOIDES* Jacq.

Distribution.—A bulbous plant with several varieties, having red, yellow, or white flowers, growing among the mountains along the eastern coast of Cape Colony.

31856. *OXYANTHUS PYRIFORMIS* (Hochst.) Skeels.

(*Megacarpa pyriformis* Hochst. 1844, *Flora*, vol. 27, p. 551.)

(*Oxyanthus natalensis* Sond. 1850, *Linnaea*, vol. 23, p. 50.)

The seeds of this South African rubiaceous shrub were received under the name *Oxyanthus natalensis*, a name given to the plant by Sonder, who transferred the species from the genus *Megacarpa* to which it was first assigned by Hochstetter in 1844. In transferring the species Sonder displaced the original specific name, *pyriformis*, which is here restored, in accordance with present rules of botanical nomenclature.

Oxyanthus pyriformis is known to occur only in the damp woods in the vicinity of Durban, South Africa.

31857. *PALLASIA CAPENSIS* Christm.

(*Calodendrum capense* Salberg 1782, in Thunberg, *Nova Genera Plantarum*, p. 43.)

The seeds of this large, evergreen South African tree, belonging to the family Rutaceae, were received under the name *Calodendron capense*. The generic name *Calodendrum* was published by Salberg in 1782. However, in 1778, Christman (Houttyn, *Pflanzensystem*, vol. 3, p. 318, pl. 22) had published for the same plant the name *Pallasia capensis*. The name *Pallasia* was first used in 1777 by Scopoli (*Introductio*, p. 72) for a grass which had been described and figured in 1770 by Pallas (*Reise durch verschiedene Provinzen des russischen Reichs*, vol. 2, p. 733, pls. K., fig. 1, and Q., fig. 2), but to which no binomial name was given.

Scopoli also wrote "an hoc *Phleum Schoenoides* Linn.?", but this is not the species described, nor the one described and figured by Pallas. Scopoli, therefore, did not technically publish the generic name *Pallasia*, as he did not use a binomial name and did not refer to any description which is associable with a previously published binomial species. It is therefore necessary to use the name *Pallasia* for the genus generally called *Calodendron*.

Pallasia capensis, called "wild chestnut" by the colonists, is found in the woods along the eastern coast of South Africa from the vicinity of Durban southward to the Cape.

31858. *PSYCHOTRIA CAPENSIS* (Eckl.) Vatke.

Distribution.—An evergreen shrub or small tree found in the woods in the vicinity of Durban in South Africa.

31859. *SPHEDAMNOCARPUS PRURIENS* (Juss.) Szyzylowics.

Distribution.—A shrubby vine growing in the woods in the Transvaal region of South Africa.

31835 to 31864—Continued.**31860. STRELITZIA ALBA (L. f.) Skeels.**

(*Heliconia alba* L. f. 1781, Supplementum Plantarum, p. 157.)

(*Strelitzia augusta* Travenfeldt 1792, in Thunb., Nova Genera Plantarum, p. 113.)

This beautiful white-flowered plant belonging to the family Musaceæ was first named in 1781 by Linnaeus's son as a species of *Heliconia*, with the specific name *alba*. Travenfeldt, in 1792, transferred the species to the genus *Strelitzia*, where it is generally considered to belong, but gave it a new specific name, *augusta*. The binomial *Strelitzia alba*, although the proper name of this plant, according to recognized nomenclatural practice, appears never to have been used heretofore.

Strelitzia alba is a well-known South African plant, occurring from Durban to the Cape of Good Hope.

31861. STRYCHNOS DECUSSATA (Pappe) Gilg.

Distribution.—A tree, attaining a height of 25 feet, the knotted twigs of which are used as ceremonial wands by the Zulu-Kafirs, is found on the eastern coast of South Africa from Durban to Uitenhage.

31862. TECOMA BERTEROI DC.

See No. 28728 for previous introduction.

31863. TURRAEA HETEROPHYLLA Smith.

Distribution.—A gray-barked shrub found in the woods in the vicinity of Durban in South Africa.

31864. TURRAEA OBTUSIFOLIA Hochst.

Distribution.—A shrub with reddish bark, growing in the woods in the vicinity of Durban in South Africa.

31865. BOUEA GANDARIA Blume.

From Singapore, Straits Settlements. Presented by the Botanical Garden at Singapore through Mr. Lyster H. Dewey, of the Bureau of Plant Industry, who brought them with him to this country on his return from abroad. Received September 20, 1911.

See No. 29383 for previous introduction.

31866. CORNUS BRETSCHNEIDERI Henry.

From Rochester, N. Y. Presented by Mr. John Dunbar, Assistant Superintendent of Parks. Received September 15, 1911.

This is a very ornamental shrub from the mountains of western China, especially striking in the winter against a background of evergreens, because of its bright lemon-yellow twigs. It has proven thoroughly hardy as far north as Rochester, N. Y.

See No. 30288 for previous introduction.

31868. HORDEUM sp.**Hull barley.**

From Khanaka, Oasis of Sandju, Chinese Turkestan. Received through Mr. Frank N. Meyer, agricultural explorer, September 11, 1911.

This seed was picked out of No. 31793, a summer barley. See this number for remarks.

31869. ANNONA GLABRA L.**Alligator-apple.**

From Camaguey, Cuba. Presented by Mr. Robert L. Luácea, agricultural engineer, at the suggestion of Mr. G. P. Wilder, Honolulu, Hawaii. Received September 21, 1911.

See No. 26855 for previous introduction.

31870. PHORMIUM TENAX Forst.**New Zealand flax.**

From Pasadena, Cal. Presented by Mr. P. D. Barnhart. Received September 7, 1911.

31871. NICOTIANA TABACUM L.**Tobacco.**

From Guatemala City, Guatemala. Presented by Mr. S. Billow. Received September 13, 1911.

"The tobacco that is principally used here is brought from Honduras. However, the other day I noted a tobacco plant growing very luxuriantly in one of the parks and plucked some of the seed, which I am sending. I do not know anything about the variety, but the stalk did not show any signs of disease or attack by insects." (Billow.)

31872 to 31876.

From Paraguay. Presented by Mr. C. F. Mead, Villa Encarnacion. Received September 23, 1911.

Seeds of the following; quoted notes by Mr. Mead:

31872. ARISTOCLESIA ESCULENTA (Arruda) Stuntz.**Pacuri.**

(*Moronobea esculenta* Arruda 1810, Discurso Sobre a Utilidade da Instituição de Jardins nas Principaes Provincias do Brazil, p. 32; reprinted in Mello, Biographias de Joacquirn Ignacio de Lima, etc., 1895.)

(*Platonia insignis* Mart. 1832, Nova Genera et Species Plantarum Brasiliensium, vol. 3, p. 169, pls. 288, fig. 2, and 289.

The seeds of this Brazilian tree, which belongs to the family Clusiaceæ, were received under the name *Platonia insignis*, which was applied to it by Martius in 1832. In 1808, however, Rafinesque (Medical Repository, vol. 5, p. 352) had published the generic name *Platonia*, based on *Verbena nodiflora* L., thus preventing the use of the same name for the tree described by Martius. This fact was recognized in 1909 by Coville, who published the new generic name *Aristoclesia* (Century Dictionary Supplement, p. 75). Martius described but one species, *Platonia insignis*, and cited *Moronobea-esculenta* Arruda, which identification was indorsed in 1896 by Britten (Journal of Botany, vol. 34, p. 248). The earlier specific name is here restored.

"In Guarany this is called *pacuri*. It is very highly recommended as a delicious fruit, either fresh or in preserves. The plant grows 2 meters [6½ ft.] high and the fruit, which is larger than a cherry and nearly black in color, is borne in clusters about the main stalk. Frost resistance equal to the orange. Seed procured near Caballero, Paraguay."

Distribution.—*Aristoclesia esculenta* is found in the aboriginal forests of the Amazon Valley in the provinces of Para, Maranhao, and Ceara in Brazil.

31873. PSIDIUM GUAJAVA L.**Guava.**

"A native of South America. Found growing wild in the mountains in Paraguay. Same description as for other guavas sent (No. 31359). This seed was selected from the largest and finest fruits only."

31874. GOSSYPPIUM sp.**Cotton.**

31872 to 31876—Continued.**31875 and 31876. ARACHIS HYPOGAEA L.****Peanut.****31875. Red.**

"This is called in Guarany *mandui colorado*, in Spanish *mani colorado*. A main-crop variety, but inferior in yield and quality to the white variety. Habit of growth same as the Virginia Runner; nuts though similar to the Tennessee Red in quality are nearly as large as the white peanut."

31876. White.

"This is called in Guarany *mandui blanca*, in Spanish *mani blanca*. Reported as a variety developed by Indians in Chaco, Paraguay, but I have doubts as to the truth of this. This is the best of the peanuts found here for main crop. A strong plant. Habits of growth similar to the Virginia Bunch and a heavy cropper. Pods large and well filled; as many as five nuts in one pod are commonly found."

31877 to 31878.

From Australia. Presented by Mr. James Pink, Wellington Point, near Brisbane, Queensland. Received September 26, 1911.

Seeds of the following; quoted notes by Mr. Pink:

31877. CITRUS AUSTRALIS (Cunn.) Planch.**Australian sour orange.**

"These were collected on the range of hills whence is the source of the Brisbane River, where in winter they occasionally get 10 to 15 degrees of frost in the early morning, but appear to suffer no harm therefrom."

31878. GREVILLEA BANKSII R. Br.

"One of the most beautiful flowering shrubs of Australia."

Distribution.—In rocky places along the coast of the province of Queensland, Australia, from Broad Sound southward to the vicinity of Brisbane.

31879. ANDROPOGON SCHOENANTHUS L.**Lemon grass.**

From Suva, Fiji Islands. Presented by Mr. Charles H. Knowles, Superintendent of Agriculture, Department of Agriculture. Received September 25, 1911.

See No. 29456 for description.

31880. ANNONA MURICATA L.**Soursop.**

From Redland Bay, Queensland, Australia. Presented by Mr. James Collins. Received September 25, 1911.

Grafted plants.

31881. CITRUS sp.**Orange.**

From Paraguay. Presented by Mr. C. F. Mead, Villa Encarnacion. Received September 27, 1911.

"This is called *Naranja apepu*. Claimed by Paraguayans as the native wild orange, but is more likely a sport from *Citrus bigarada de grandes frutas*. The strongest growing and hardiest of all oranges here; seems to be affected by neither drought nor floods, heat or cold, and is free from all diseases common here. The fruit is large, neither sweet nor sour; skin very thick and free, used to some extent for oil and preserves. Tree grows to a height of 4 or 5 meters [13 or 16 ft.]. This seed came from a tree having a trunk 8 inches in diameter, which eight months ago was girdled 2 inches deep all around to kill it; fruit of this crop better than ever. This orange may be of use as a rootstock." (*Mead.*)

31882. MEIBOMIA sp.

From Puerto Bertoni, Paraguay. Presented by Dr. Moises S. Bertoni, Estacion Agronomica. Received September 18, 1911.

"This is a native species of Paraguay, very good for forage and extraordinarily resistant to drought. It grows well in any soil, even in the driest and most sterile." (Bertoni.)

31883. VACCINIUM ANGUSTIFOLIUM Aiton.**Blueberry.**

From Cape Breton Island, Nova Scotia. Received through Mr. David Fairchild, of the Bureau of Plant Industry, September 28, 1911.

These plants were introduced for purposes of botanical study and breeding work.

Distribution.—Northeastern America; Hudson Bay region, Labrador, and Newfoundland, and southward to the alpine slopes of the White Mountains in New Hampshire.

31884 to 31890. PHORMIUM TENAX Forst.**New Zealand flax.**

From Wellington, New Zealand. Presented by Mr. T. W. Kirk, director, Department of Agriculture. Received September 26 and 27, 1911.

Plants of the following:

- | | |
|------------------------------------|---------------------------------|
| 31884. <i>Tamatea.</i> | 31888. <i>Huhiroa.</i> |
| 31885. Seedling (no name). | 31889. <i>Ngutunui.</i> |
| 31886. <i>Tutaemanu.</i> | 31890. <i>Wharariki.</i> |
| 31887. <i>Parekawariki.</i> | |

31891. ANNONA PURPUREA Moc. and Sesse.**Cabeza de negro.**

From Mexico. Presented by Mr. C. B. Waite, City of Mexico, Mexico. Received September 29, 1911.

"This fruit is not a very valuable one in my estimation, although it is esteemed by the natives. It is fragrant, stringy, yellow, almost insipid, and will average in weight about 3 pounds. It has skin, turning brown when ripe, and ripens in August and September. The trees are about 10 to 15 feet high. The pulp of the fruit clings to the seed, like the mango, but does not seem to have the strings growing out of the seed as the mango, but out of a sheath around the seed. It is common from Cordoba to Guatemala." (Waite.)

31892. MEDICAGO SATIVA L.**Alfalfa.**

From Peking, China. Presented by Mr. B. Laufer. Received September 28, 1911.

31893 to 31895. HORDEUM spp.**Barley.**

From Komaba, Tokyo, Japan. Presented by Dr. Y. Kozai, director, Agricultural College, Tokyo Imperial University. Received September 27, 1911.

Seeds of the following:

- 31893.** "*Bozu.* Ordinary variety."
31894. "*Ischadaka.* Naked variety."
31895. "*Kawai.* Naked variety and having awns on two rows of spikelets only."

31897. ERAGROSTIS ABYSSINICA (Jacq.) Schrad.**Teff.**

From the Transvaal, South Africa, at an elevation of 5,000 feet. Presented by Prof. J. Burt Davy, government agrostologist and botanist, Transvaal Department of Agriculture, Pretoria. Received September 30, 1911.

"This is one of my most valuable introductions into South Africa, and I am anxious that it should receive attention in the Southern and Southwestern States as a hay crop.

"Its great value lies in the rapidity of its growth and maturity (2 to 2½ months), and I have heard of a crop having been grown near Bloemfontein with only 4 inches of rain.

"Being sensitive to frost it is only suitable for regions of summer rainfall, which may partly account for the fact that it never 'took' among the farmers of California, where I introduced it many years ago." (Davy.)

31898 and 31899.

From South Africa. Presented by Prof. J. Burt Davy, government agrostologist and botanist, Transvaal Department of Agriculture, Pretoria. Received September 30, 1911.

Seeds of the following:

31898. ACACIA KIRKII Oliver.

Distribution.—The highlands of the Batoka country in Lourenco Marques, on the east coast of Africa.

31899. CAILLIEA NUTANS (Pers.) Skeels.

(*Mimosa nutans* Pers. 1807, Synopsis Plantarum, vol. 2, p. 266.)

(*Cailliea dichrostachys* Guill. and Perr. 1830-1833, Florae Senegambiae Tentamen, vol. 1, p. 240.)

(*Dichrostachys nutans* Benth. 1842, The Journal of Botany, vol. 4, p. 353.)

The seeds of this South African leguminous shrub were received under the name *Dichrostachys nutans*. The generic name *Dichrostachys* was published in 1834 by Wight and Arnott (Prodromus Florae Peninsulae Indiae Orientalis, vol. 1, p. 271) with one species, *D. cinerea*, based on *Mimosa cinerea* L. In 1833, however, Guillemin, Perrottet, and Richard had published the genus *Cailliea* with one species, *C. dichrostachys*, based on *Mimosa nutans* Pers., which is considered to be congeneric with *Mimosa cinerea* L. In establishing the genus *Cailliea* the authors used for the specific name of their plant, *dichrostachys*, which had been used by De Candolle (Prodromus, vol. 2, 1825, p. 445) for a section of the genus *Desmanthus* but which was not published as a generic name until 1834. The earlier generic and specific names are both here restored.

Cailliea nutans is found on the west coast of Africa from Sierra Leone southward to Angola and on the east coast from Abyssinia southward to Mozambique.

"Both of these are shrubs or small trees and the pods are eaten by game and stock, much as is the case with the mesquite of the Southwest. The wood of *Dichrostachys nutans* (*Cailliea nutans*) is very hard and durable and is much valued in termite-infested regions for fence posts, in spite of its usually crooked habit of growth. It is known as *Sikkelbosch* or *Krul-peul*.

"Both bushes are native of the warm, dry middle veld below 4,000 feet and are usually found in sandy or gravelly soils in regions where the rainfall is from 20 to 25 inches, falling in summer." (Davy.)

31900 to 31902. HORDEUM spp.**Barley.**

From Nishigahara, Tokyo, Japan. Presented by Dr. Kozai, director, Agricultural College, Tokyo Imperial University. Received September 28, 1911.

Seeds of the following; quoted notes by Prof. Kozai:

31900. HORDEUM sp.

Saitama-Nishiki.

31901. HORDEUM INTERMEDIUM Koernicke.

Bodzu.

31902. HORDEUM sp.

Nakano-Wase.

"These varieties are cultivated in the western part of our country from olden times and, though their origin is unknown, it may be supposed that they are the result of natural hybridization."

31903 to 31907.

From Puerto Orotava, Teneriffe, Canary Islands. Presented by Dr. George V. Perez. Received September 25, 1911.

Seeds of the following; quoted notes by Dr. Perez:

31903. OCOTEA FOETENS (Soland.) Benth. and Hook.

"A laurel of our flora called *Til*. This is undoubtedly the sacred tree of the island of Hierro which used to condense the mountain mist into water and supply the inhabitants with drinking water. Should be grown in California in localities where mountain mists prevail."

31904 and 31905. CYTISUS spp.

"Two sorts of the famous mountain broom of Teneriffe, renowned for its beautiful flowers, which are an ideal food for bees. It grows between 7,000 and 9,000 feet and would do well in the mountains of southern California."

31904. CYTISUS CANARIENSIS RAMOSISSIMUS (Desf.) Briquet.

31905. CYTISUS SPACHIANUS (Webb) Kuntze.

31906 and 31907. CYTISUS SUPRANUBIUS (L. f.) Kuntze.

"Two very rare Teneriffe cytisi. Should be grown in California or Florida."

31908 to 31913. IPOMOEA BATATAS (L.) Poir.**Sweet potato.**

From Tauranga, New Zealand. Presented by Mr. W. C. Berridge, manager, Experimental Farm, Department of Agriculture, Commerce, and Tourists, Tauranga. Received September 29, 1911.

Tubers of the following; quoted notes by Mr. Berridge:

31908. Red Waina.

"This is like the Red Bermuda, or the variety I grew many years ago under that name. The name *Waina* is an attempt by the Maoris to pronounce vine, i. e., a sweet potato grown by sets or pieces of the vine."

31909. White Waina.

"Same as the preceding except in color."

31910. Uti-uti.

"Pronounced *Hooty-hooty*. This variety is grown from sections of the tuber cut in lengths of 1 to 2 inches. Planted on ridges it does not make much vine."

31908 to 31913—Continued.

31911. Red, from Japan.

"Looks somewhat like Red Jersey. I have not grown it yet, as the tubers were received recently."

31912. *Rekaumauroa* or *Tariana*.

"A dry sweet potato much liked by the Maoris. The meaning of the name is 'sweet forever'."

31913. *Taroamahoe*.

"This small sweet potato is liked by the Maoris, as it is dry and mealy, although small. Tradition says the natives brought it with them about 400 years ago when they first came to New Zealand from Hawaiki (Hawaii (?))."

31914 to 31923. DIOSCOREA spp.**Yam.**

From Port Moresby, New Guinea. Presented by Mr. J. A. Hamilton. Received July 31, 1911. Numbered September 30, 1911.

Tubers of each of the following:

31914. *Mordai*.

31920. *Walconco* (?).

31915. *Keresga*.

31921. *Wanse* (?).

31916. *Gorana*.

31922. *Hasalik* (?).

31917. *Sanai*.

31923. This number was given to

31918. *Howtai*.

three tubers, from which

31919. *Sargo*. Reddish, very fair

the names had evidently

for table.

been lost.

31925. (Undetermined.)

From Australia. Presented by Mr. B. Harrison, Burringbar, New South Wales. Received July 31, 1911. Numbered September 28, 1911.

"A native cherry." (*Harrison*.)

31927. ANDROPOGON SORGHUM (L.) Brot.**Sorgo.**

From San Jose, Costa Rica. Presented by Mr. Carlos Wercklé. Received May 2, 1911. Numbered September 30, 1911.

"This is a sorgo of the section which contains the Amber, Early Amber, Minnesota Amber, etc. From the appearance of the head I infer that it grew in a field seeded very thickly and that the heads are not at all normal in shape or size. I would suggest that it be grown for determination." (*Carleton R. Ball*.)

31928 to 31931.

From Costa Rica. Presented by Mr. Carlos Wercklé, San Jose, Costa Rica. Received September 18, 1911. Numbered September 28, 1911.

31928. *PERSEA PITTIERI* Mez.

Avocado.

See No. 32173 for later introduction of this species.

31929. *ANNONA PURPUREA* Moc. and Sesse.

Distribution.—Found in southern Mexico, in Panama, and Costa Rica.

31930. *GEONOMA* sp.

Palm.

"A superb palm." (*Wercklé*.)

31931. *COCCOLOBIS* sp. (?)

"Seeds of a carrocaliente, but not the one from the Pacific coast. Is from the mountains. Is esteemed." (*Wercklé*.)

See No. 31636 for other species introduced.

31932. IPOMOEA MAMMOSA (Lour.) Choisy.

From Java. Presented by Mr. M. Buysman, Lawang, Java. Received September 18, 1911.

"This tuber is reported to be a very good medicine in case of diabetes. It is cut in slices or scraped and the mass pressed in a linen sack with water. This water is drunk the entire day. I doubt if it is successful in all cases. The plant can be grown in the Southern States, Florida, and California." (*Buysman.*)

31933. MANIHOT ESCULENTA Crantz.**Cassava.**

From Paraguay. Received through Mr. C. F. Mead, Villa Encarnacion, September 14, 1911.

"Called in Guarany *mandio yeruti*, in Spanish *mantioca*. A sweet variety of cassava, which is dwarf in habit, attaining a height of only 2 meters [6½ ft.] This is of splendid quality for table use, but in no way out of the ordinary, except that the root crop is mature in five months. In Paraguay they plant canes of this variety in August and the root is ready by the end of December. Requires a light sandy loam, not too rich or the plant will run to canes. This variety is for table use, other varieties giving better results for stock crops, where a larger yield is important. From my experience I recommend *mantioca* highly as an excellent vegetable." (*Mead.*)

31934. ACHRAS sp.

From Costa Rica. Presented by Mr. Carlos Wercklé, San Jose. Received August 14, 1911. Numbered September 28, 1911.

"A *sapotilla*. Large, very high quality; rose-colored flesh; four small seeds in each fruit." (*Wercklé.*)

31935. ZIZIPHUS sp.

From Costa Rica. Presented by Mr. Carlos Wercklé, San Jose, Costa Rica. Received August 14, 1911. Numbered September 28, 1911.

31936 to 31938. MANGIFERA INDICA L.**Mango.**

From Philippine Islands. Received through Mr. C. V. Piper, of the Bureau of Plant Industry, August 9, 1911. Numbered September 28, 1911.

Señora.

"These mango seeds were obtained by Mr. P. J. Wester, in Muntinlupa, Rizal Province. This mango is of very limited distribution, only a very few trees having come to our attention. The fruit is very much smaller than either the *Carabao* or *Pico*, and has more fiber and a larger seed in proportion to the flesh than either of these varieties. The quality is very good, but we do not believe that it has any possibilities as a commercial fruit." (*O. W. Barrett, chief, Division of Experiment Stations, Manila, P. I.*)

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- 31491.** *AGROSTIS* sp.
31498. *CALAMAGROSTIS YOUNGII* (Hook. f.) Skeels.
31501. *SAVASTANA FRASERI* (Hook. f.) Skeels.
31503. *POA AUSTRALIS* R. Br.
31571. *SYZYGIUM CUMINI* (L.) Skeels.
31639. *RHUS VERNICIFLUA* Stokes.
31736. *CAJUPUTI LEUCADENDRA* (Stickman) Rusby.
31850. *MILLETTIA GRANDIS* (E. Meyer) Skeels.
31856. *OXYANTHUS PYRIFORMIS* (Hochst.) Skeels.
31857. *PALLASIA CAPENSIS* Christm.
31860. *STRELITZIA ALBA* (L. f.) Skeels.
31872. *ARISTOCLESIA ESCULENTA* (Arruda) Stuntz.
31899. *CAILLIEA NUTANS* (Pers.) Skeels.

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BUREAU OF PLANT INDUSTRY—BULLETIN NO. 249.
B. T. GALLOWAY, *Chief of Bureau.*

THE BRANCHING HABITS OF EGYPTIAN COTTON.

BY

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Investigations.*

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., March 12, 1912.

SIR: I have the honor to transmit herewith a paper entitled "The Branching Habits of Egyptian Cotton," by Mr. Argyle McLachlan, of this bureau, and to recommend its publication as Bulletin No. 249 of the bureau series. More definite information regarding the habits of branching of the Egyptian cotton has been required in developing a system of cultivation adapted to the irrigated districts of southern California and Arizona.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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THE BRANCHING HABITS OF EGYPTIAN COTTON.

INTRODUCTION.

That the cotton plant produces two distinct types of branches which are variously developed in the different varieties and types of cotton and under different conditions of growth has been known for several years. The agricultural importance of these different habits of branching and the need of more careful study of such facts in relation to problems of breeding and acclimatization have been pointed out.¹ The excessively large size of the vegetative branches on Egyptian cotton plants grown under irrigation in the Colorado River Valley in Arizona and California has necessitated a detailed study of these problems. Not only does this excessive vegetative growth occasion difficulties in cultivation and harvesting, but it causes the development of normal fruiting branches to be postponed. To place the growing of Egyptian cotton in the Southwest on a practical basis, cultural control of the production and development of vegetative and fruiting branches must be established. A study of the branching habits of Egyptian cotton is necessary as a preliminary investigation of this problem.

The present paper gives the results of investigations of the branching habits of Egyptian cotton during the seasons of 1909 and 1910.

In 1909 one-acre plats of several important varieties were under observation at Somerton, in the Colorado River Valley, south of Yuma, Ariz., besides larger field plantings of two strains which have undergone several years of selective breeding. Plats on the Pima Indian Reservation at Sacaton, Ariz., and near Los Angeles, Cal., including plantings of both imported and acclimatized seed, were also studied. The observations were made throughout the growing, fruiting, and mature stages of the plants. During the season of 1910 a series of Egyptian cottons planted throughout California and at Yuma and Sacaton in Arizona yielded corroborative evidence of the facts established in 1909.

¹ Cook, O. F. Weevil-Resisting Adaptations of the Cotton Plant. Bulletin 88, Bureau of Plant Industry, U. S. Dept. of Agriculture. 1906. See also "Dimorphic Branches in Tropical Crop Plants: Cotton, Coffee, Cacao, the Central American Rubber Tree, and the Banana," Bulletin 198, Bureau of Plant Industry, U. S. Dept. of Agriculture. 1911.

TWO TYPES OF BRANCHES IN COTTON.

The two kinds of branches of the cotton plant are distinguished as vegetative branches and fruiting branches. (Pl. I, fig. 1.) Vegetative branches or "limbs" are borne either directly in the angle of the leaf with the stem (axillary position) or at one side or the other of the angle (extra-axillary position). Fruit-bearing branches occur only in the extra-axillary position and are called "fruiting branches." Vegetative branches are counterparts of the main stem in that they also bear branches, both vegetative and fruiting, which are distinguished as "secondary vegetative branches" (or "secondary limbs") and "secondary fruiting branches," respectively. In the present paper these terms will be used in conformity with these definitions.

GENERAL CHARACTERS OF THE BRANCHING HABITS OF EGYPTIAN COTTON.

Egyptian cotton plants, as grown in Arizona and southern California, produce a large number of limbs from the lower nodes of the main stalk. These limbs often attain nearly the size of the main stem or axis and are of more practical importance to the Egyptian plant than to the Upland varieties. (Pl. I, fig. 2.) The latter also bear limbs at low nodes, but not in such numbers as the Egyptian types, and both limbs and fruiting branches often occur together at low nodes of the stem. In Egyptian cotton the large basal limbs are never accompanied by fruiting branches, i. e., the fruiting branches, which occur only in the extra-axillary position, do not arise in the Egyptian cottons from the same nodes which bear the large vegetatives. Because of this fact no fruiting branches occur on the Egyptian stalks until at a relatively high node, which varies with the variety and among individuals of the same variety. (Pl. I, fig. 2, and Pl. II, figs. 1 and 2.)

The axillary limbs which occur infrequently, and then only when paired at the same nodes with extra-axillary limbs or with lower fruiting branches, are small and of relatively little importance. Because the vegetative and fruiting branches are thus to be found almost isolated one from the other on the stem, a fairly distinct condition of branch zones prevails in all Egyptian cotton plants.

THREE BRANCH ZONES IN THE EGYPTIAN COTTON PLANT.**ZONE OF VEGETATIVE BRANCHES (NODES 3 TO 10).**

The Egyptian cotton plant may be divided into three branch zones. The position of these zones is graphically shown in figure 1. The zone of vegetative branches includes the first 10 nodes at the



FIG. 1.—YOUNG EGYPTIAN COTTON PLANT DENUED OF LEAVES, SHOWING LARGE LIMBS ARISING AT THE BASE OF THE STEM AND SLENDER FRUITING BRANCHES FROM LOCATIONS HIGHER ON THE STEM. SECONDARY FRUITING BRANCHES BORNE BY THE LIMBS ARE ALSO SHOWN.



FIG. 2.—MATURE EGYPTIAN COTTON PLANT WITH EXCESSIVE DEVELOPMENT OF LIMBS.



FIG. 1.—MATURE EGYPTIAN COTTON PLANT WITH A NUMBER OF MEDIUM-SIZED LIMBS, SHOWING DIFFERENCE IN SIZE AND POSITION OF LIMBS AND FRUITING BRANCHES. THE LONG BRANCHES AT THE BASE OF THE PLANT ARE LIMBS; THE SHORTER BRANCHES APPEARING JUST ABOVE THE LIMBS AND CONTINUING TO THE TOP OF THE STEM ARE FRUITING BRANCHES.

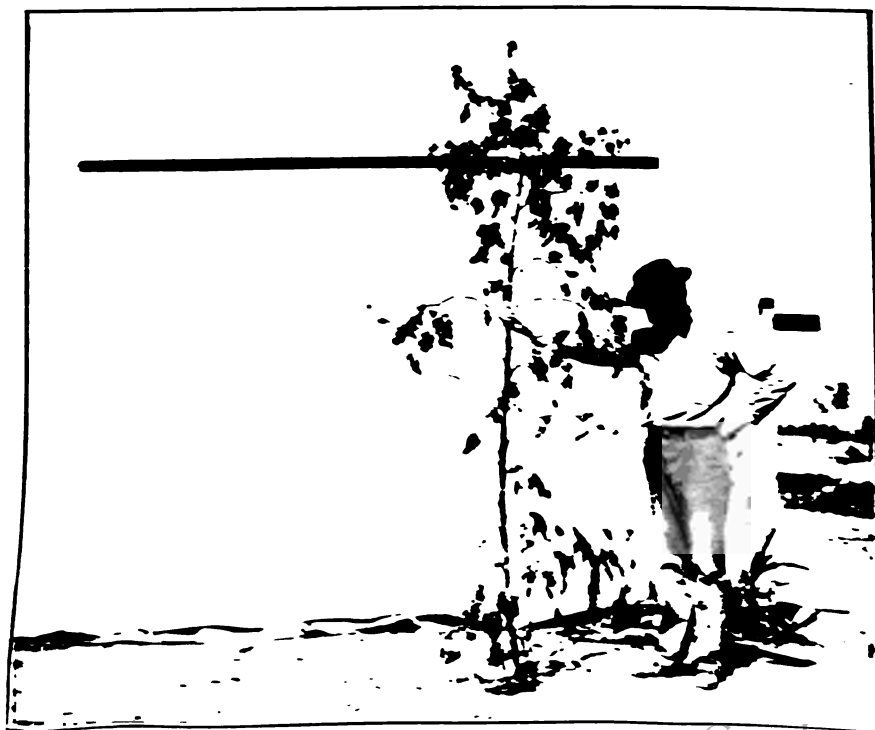


FIG. 2.—MATURE EGYPTIAN COTTON PLANT WITH LIMBS SUPPRESSED.

base of the stalk, which usually produce from 6 to 10 limbs. The extent of this zone varies in different individuals. Limbs may develop as high as the twelfth or even the fourteenth node, but this is rather an extreme limit.

ZONE OF RUDIMENTARY BRANCHES, OR TRANSITION ZONE.

Between the limbs and the fruiting branches there are usually two or three nodes at which the buds remain dormant, or the branches

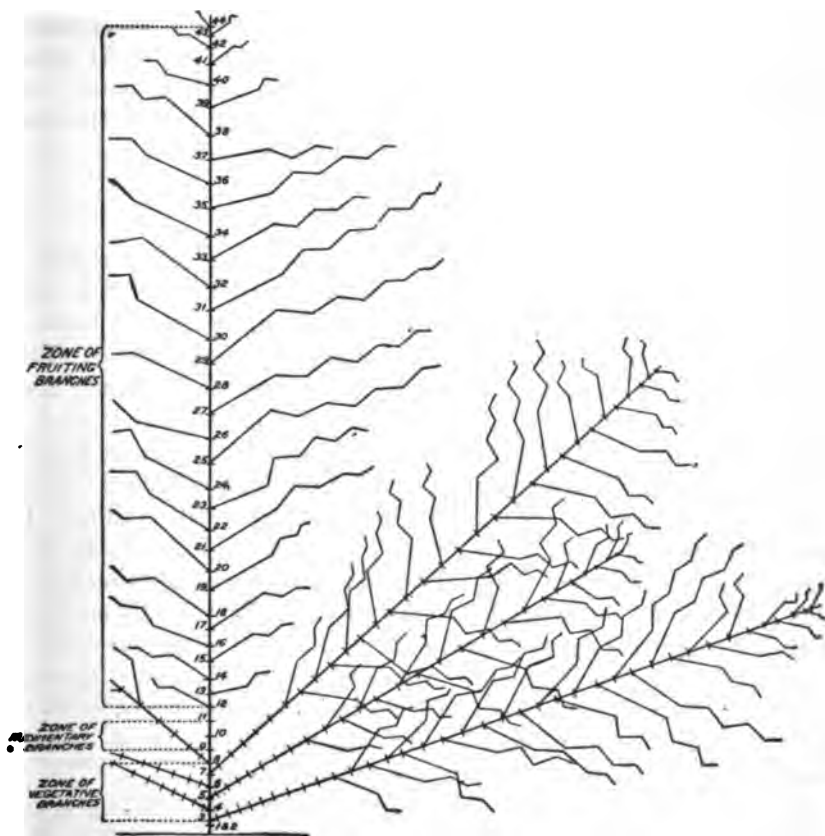


FIG. 1.—Diagram of an Egyptian cotton plant, showing the nature of branching in the Yuma variety, an acclimatized strain. The perpendicular line represents the axis which bears vegetative branches or limbs (straight lines) and fruiting branches (zigzag lines); the zigzag lines arising from the limbs are the secondary fruiting branches. The zone of rudimentary branches is indicated at three nodes between the limbs and the fruiting branches. The nodes of the axis are numbered.

are extremely short or abortive. For convenient reference, this region is termed the zone of rudimentary branches. It is not uncommon to find in this zone fruiting branches, a few inches in length, with all flower buds absorbed, sometimes accompanied by an abortive or abnormal axillary limb. This portion of the stem may be looked

on as the zone of transition from the vegetative to the fruiting condition. Infrequently a large limb occurs at a node above this transition zone.

In this zone of undeveloped branches many irregularities occur, indicative of the transition state of the branches. One of the plants, which was carefully measured during the spring of 1909, had the position of the fruiting branch and limb reversed at successive nodes in this zone. An abortive fruiting branch at node 9 was borne on the left of the leaf axil; the axillary limb at the same node was growing rapidly. At all succeeding nodes the relation was reversed, the fruiting branch being on the right side of the axil. At a later stage in the growth of this plant the axillary limb at node 9 was found to be abnormal, while the extra-axillary branch at this node remained abortive, as was the axillary branch at node 10.

ZONE OF FRUITING BRANCHES.

The first fruiting branches are borne at nodes directly above the zone of undeveloped branches. On many plants the first few fruiting branches may be short, with flowers abortive and the branches determinate after one or two branch nodes have been formed. These branches are very slender and weak. The zone of developed fruiting branches usually begins at or near the thirteenth node and extends to the top of the plant, each node normally bearing a fruiting branch. The fertile zone may be divided into two subzones. At the nodes which produce the first fruiting branches the axillary bud may be developed into a slender limb. The number of nodes at which this occurs is restricted, only a few nodes bearing a fruiting branch and a limb. As discussed later, the small axillary limbs occurring with fruiting branches are apparently of different character from the large limbs lower on the plant. Above where limbs occur at the same node with fruiting branches, short axillary branches are often developed in addition to the regular fruiting branches. These resemble short fruiting branches and bear one or two flowers.

It has been suggested that this apparently axillary fruiting branch represents a secondary fruiting branch borne by the axillary limb, which is itself suppressed, but which sometimes appears to be represented by a very small bud at the base of this seemingly axillary fruiting branch. An alternative explanation, which may be justified by the apparent mutability of the branch types in Egyptian cotton, is that there has been a complete transformation in some cases from the axillary limb to an axillary fruiting branch. It has been observed that the flower of one of these apparently axillary fruiting branches sometimes blooms as early as the day following the flower at the first node of the accompanying fruiting branch.

These fruiting branches which occur in the axillary position often grow from the side of the base of the regular fruiting branch, a condition which may represent a partial fasciation, though the small fruiting branch appears to be borne by the larger branch. These axillary branches are always short, the terminal vegetative bud aborting after one or two squares have been set. At the lowest nodes where such branches appear they normally bear a leaf opposite the flower bud, but at higher nodes the leaf may be abortive and the branch appear as a very long flower stem borne directly on the main stalk of the plant. The axillary branches usually abort and drop off at most of the nodes while in the condition of very small buds, but, nevertheless, the buds are formed with regularity on both main stem and limbs. In an acclimatized stock of Egyptian cotton grown at Somerton, Ariz., the axillary buds were retained at some of the nodes where they first appeared, aborted at from 15 to 20 nodes above this, leaving well-defined scars, but were again retained at the top of the main axis and limbs, and more constantly than where they first appeared lower on the stem. This was observed late in October on plants which were 8 to 10 feet tall, with 40 to 46 nodes, and still growing.

REGULAR SEQUENCE OF BRANCH DEVELOPMENT IN EGYPTIAN COTTON.

Buds occur in all leaf axils, including those of the cotyledons or seed leaves. For convenience, the nodes of the main axis may be numbered from the base of the plant with the nodes of the cotyledons considered as the first two nodes, the first true leaf coming from the third node. This does not seem illogical, since one of the cotyledons usually stands slightly higher than the other. There is generally a regular sequence of branch development from the lower nodes upward.

Under some conditions limbs may grow from buds in the axils of cotyledons. At Glendale, Cal., in 1910, 30 plants grown from imported Mit Afifi seed bore limbs at 42 of the 60 nodes of the cotyledons; in many cases buds at both of the cotyledon nodes of a plant developed. A row of 30 plants of the acclimatized Yuma variety¹ bore 39 limbs at the 60 nodes of the cotyledons.

Branches usually do not begin to develop until from 6 to 10 true leaves have appeared on the main stem, though exceptions occur when the plants in a row are thinned very early, and are thus given more space for lateral growth. There are also individual differences in this regard, some plants deferring the development of branches

¹ The Yuma variety was originated by Mr. T. H. Kearney from stock derived from imported Mit Afifi Egyptian seed. A detailed account of the origin and development of this variety can be found in Bulletin 200 of the Bureau of Plant Industry, entitled "Breeding New Types of Egyptian Cotton," p. 13 et seq.

much longer than others. Though the branch buds appear when the accompanying leaves are yet small, they usually remain dormant for a considerable period.

On May 11, 1910, nearly two months after planting, a census of 550 of the most forward plants, bearing 6 to 8 leaves, showed the largest branches to be less than an inch in length. In this case the development of the plants was somewhat retarded by cool weather, though later plantings, which had all the warmth necessary for rapid growth, exhibited a similar dormancy of buds.

Within the lower or vegetative zone an absolute sequence of position and size of branches does not obtain. It is usual for some of the lower nodes to remain permanently dormant, so that only five or six branches commonly develop from the first 8 or 10 nodes of the plant. Of the limbs that do develop, the lowest is not necessarily the largest. In 28 per cent of the 550 plants already referred to the largest early branch was at the third node, in 28 per cent at the fourth node, and in 26 per cent at the fifth node. In the remaining 18 per cent of the plants there was no noticeable difference between the size of the branches at the third, fourth, and fifth nodes. A few cases have also been observed where the largest early branch was at the sixth node.

In the zone of fruiting branches, however, a more uniform development is observed. Here, with the exception of the first few nodes, at which buds may be dormant or where the fruiting branches may be abortive or have a determinate growth, each node usually produces a fruiting branch with regularity. Dormant branch buds are uncommon in the upper part of the plant.

In the branches of young plants a general sequence of diminishing size obtains from the base of the plant to the top, so that the first fruiting branch, which may occur at node 12, is in regular order shorter than the limb at the node next below. In older plants the greater development of limbs and the accidents of abortion obscure this regular sequence of size.

DISTINCTION BETWEEN FRUITING AND VEGETATIVE BRANCHES.

The chief distinction between fruiting and vegetative branches is that fruiting branches bear a flower bud at each node opposite the leaf, while limbs bear no flower buds. By this character fruiting branches are early distinguishable from limbs, the first small flower bud or square of the fruiting branch being apparent about as soon as the first leaf of the young branch begins to unfold.

The limbs at nodes below the first fruiting branch grow to great length, developing sometimes as many as 50 nodes and occasionally attaining a length equal to that of the main stem. In contrast to

these, the mature fruiting branches seldom have more than 12 nodes, usually only 6 or 8, and are proportionately shorter than the limbs.

Unlike the vegetative limbs, the first internode of the fruiting branch grows very rapidly and reaches almost its full length before the second internode begins to grow. This first internode is often three or four times as long as the basal internode of limbs on the same plant. Because of this the distinction between fruiting branches and limbs is much more apparent in Egyptian cotton than in Upland cotton, where the internodes of all branches are more nearly of the same length. Although the first internode of fruiting branches of Egyptian cotton is usually from 6 to 8 inches in length, great variations, due to locality and cultural conditions, have been noted and are discussed later.

A minor distinction between limbs and fruiting branches in young plants is the wider angle with the stem that is made by the fruiting branches. As the branches grow and become heavier this difference becomes more obvious. The angle which the limbs form with the stem increases as their weight increases, but their rigidity exceeds that of the fruiting branches and maintains them at a comparatively acute angle with the stem. The mature fruiting branches, which are slender and comparatively more heavily laden, assume an even wider angle with the stem and finally become pendent, in some cases almost vinelike in appearance.

FRUITING BRANCHES REPLACED BY VEGETATIVE BRANCHES.

A limb may take the place of a fruiting branch, not only in the lower part of the plant but even at nodes above those that have begun to develop normal fruiting branches. Such replacements of fruiting branches by vegetative branches usually occur at the first or second node above the first fruiting branch. These vegetative branches develop after the fruiting branches below and before those above and in the regular extra-axillary position of fruiting branches, thus appearing to belong to the regular sequence of the branching system. Nevertheless they behave as true limbs, lacking the long first internode and the flower buds which characterize fruiting branches. Out of 30 plants taken at random in a field planted to an acclimatized stock of an Egyptian strain (Yuma variety) two plants were found to exhibit this phenomenon. In 1910 a conjugate hybrid plant between Mit Afifi Egyptian and Triumph cotton (a short-staple American Upland) in which the first fruiting branch appeared at node 12 bore an extra-axillary limb at node 13 and another at node 14. Fruiting branches were borne at node 15 and at all succeeding nodes.

TRANSFORMATION OF FRUITING BRANCHES INTO VEGETATIVE BRANCHES.

Branches which began their development as fruiting branches often appear to change to limbs, even after producing buds at the first or second node. The flower buds on such branches are seldom, if ever, matured. Branches of this intermediate form are rather common and usually occur at the first few nodes in the zone of fruiting branches. Among 10 plants of an upright type grown from imported Mit Affi seed 6 bore branches of this nature, all of which were confined to the first 4 fruiting-branch nodes of the stem. Two of these transformed branches occurred just below the first normal fruiting branch, 3 just above it, and 1 each above the second and the third fruiting branches.

Another intermediate form of branch has no flower buds, though the first node grows very long, as in the typical fruiting branch. Analogies between these abnormal intermediate forms of branches and sterile hybrids have been pointed out by Mr. Cook in his discussion of branching in tropical crop plants.¹

These "hybrid" branches often are to be recognized by their larger diameter and greater length. They usually take on the vegetative habit of limbs, becoming much stronger and more rigid than fruiting branches. Several branches of this class occurred as high as the twentieth or twenty-fifth node in Mit Affi plants grown from imported seed, their exceptional nature being apparent from their sharp contrast in size with the fruiting branches at nodes above and below. They were three times as thick at the base as the fruiting branches and averaged 18 nodes to the branch. They were still growing, while the fruiting branches had only six or seven nodes and were determinate, the apical bud having aborted. These transformed branches retained the pendent form of fruiting branches, though fruit was borne only at the first node or two. The remainder of the branch gave no indication, even by the presence of a scar, that it was fertile beyond these first two nodes.

HOMOLOGY BETWEEN LARGE BASAL LIMBS AND FRUITING BRANCHES.

In the Egyptian cotton plant the large basal limbs in the zone of vegetative branches appear homologous to the fruiting branches of the main stem rather than to the small limbs which occur higher on the plant in the zone of fruiting branches. As previously stated, a large lower limb and a fruiting branch are never found at the same node in Egyptian cotton; the small upper limbs, which are axillary,

¹ Cook, O. F. Dimorphic Branches in Tropical Crop Plants: Cotton, Coffee, Cacao, the Central American Rubber Tree, and the Banana. Bulletin 198, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1911, p. 24.

occur only with fruiting branches or very infrequently with large limbs. While the earliest lower limbs appear to arise from the axil of the leaf, limbs at later nodes in the zone of vegetative branches become more and more displaced from the axil, so that those in the upper limits of this zone can be seen to arise outside the axil and on the same side of the axil as the fruiting branches at nodes just above. This can be seen most readily in young plants while the limbs are small. On the other hand, the position of the small upper limbs is unquestionably axillary. Cases have already been cited of large extra-axillary limbs at nodes above those bearing the earliest fruiting branches, but unaccompanied by fruiting branches at the same nodes. In such cases it is apparent that the limb replaces a fruiting branch and is evidently of the same nature as the lower limbs. Furthermore, under some conditions fruiting branches which are always extra-axillary are found among the lower limbs, being borne at very low nodes (6-8) in a stock of Egyptian cotton which usually bears large limbs at these low nodes; in such instances no large limbs accompanied these low fruiting branches.

That the large limbs of the zone of vegetative branches are not homologous to the limbs outside this zone is shown by the further fact that the latter, though sometimes long, are usually slender and weak and bear secondary fruiting branches only at very late nodes, while the lower limbs are robust and bear secondary fruiting branches at comparatively early nodes.

ABORTION OF FRUITING BRANCHES.

The lower fruiting branches often abort the terminal bud after setting one or two bolls, and even these bolls may be poorly nourished and consequently undersized. A few of the early fruiting branches may retain no fruit at all. This may be brought about by the appropriation of moisture for the luxuriant and rapid growth which the plant makes after these first fruiting branches are put forth. It was noticed that plants in the sandy part of the field at Somerton, Ariz., in 1909, aborted their leaf buds on all fruiting branches. In other parts of the same field, where the soil did not dry out so rapidly, no such blasting of the leaf buds took place. The plants growing in sandy soil had thus ceased to produce new bolls at a period when fruiting branches in other parts of the field were growing normally and fruiting was uninterrupted. Overshading of the lower fruiting branches has been suggested as a possible explanation of their frequent failure to develop normally, but the shading is not necessarily greater than in Upland varieties, where the lowest fruiting branches are generally the most heavily laden. In Egyptian cotton this is seldom the case.

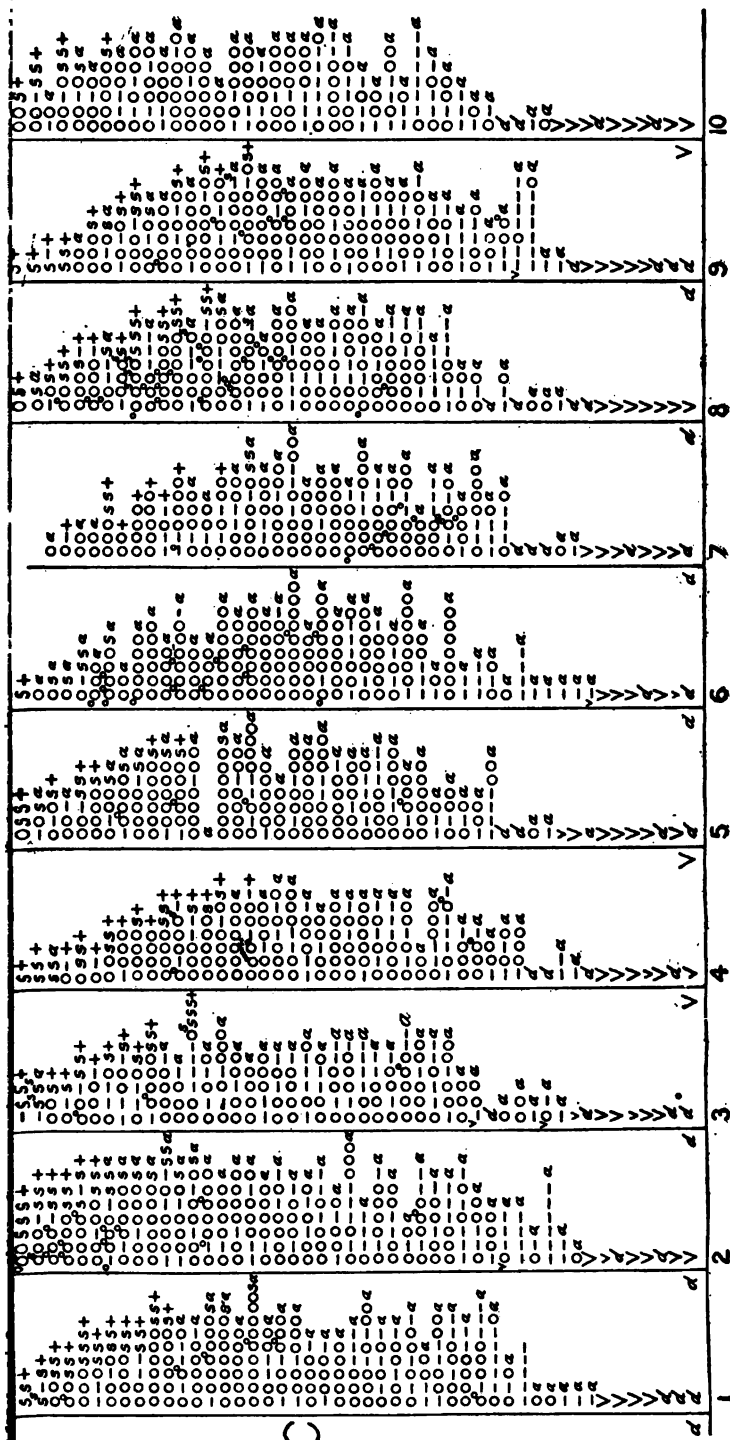
IMPORTANCE OF SELECTION FOR LOW FRUITING BRANCHES ON THE MAIN AXIS.

Selection for low-fruited branches may be a practical means of increasing the yield and earliness of Egyptian cotton. It was found that one of the most productive of the acclimatized stocks consistently bore fruiting branches lower on the stem than any other stock of Egyptian cotton being grown at Sacaton, Ariz., in 1910. This stock was from a selection made at Sacaton in 1909 by Mr. E. W. Hudson, of the Bureau of Plant Industry. Some superiority over imported stocks is shown by other selected strains in their habit of developing fruiting branches at low nodes of the stem, though the strains were not selected originally for low-fruited branches. That a larger yielding type can be secured in this way without affecting the quality of the fiber seems probable, as the fiber in the Egyptian cotton, the Yuma variety in particular, holds up in quality and length remarkably well under the various conditions which occasion the diversities in branching.

In plantings from imported seed of Egyptian varieties in Arizona and California considerable diversity has existed as to the height on the stem of the first fruiting branch. Nubari, a new variety, planted in the United States for the first time in the season of 1909, has behaved more like the acclimatized stocks and gives good promise of rapid adjustment to conditions in the southwestern United States. From what is known in regard to close planting in Egyptian field culture, it seems likely that the Egyptian cotton has never received selection for the development of low-fruited branches. Close planting, which would almost preclude selection of any sort, would also naturally tend to suppress the lower-fruited branches. The assumption that low fruiting—the development of the early fruiting-branch buds and the retention of a large percentage of flower buds—is the normal habit of the plant seems reasonable, since, in all plantings which have been observed, plants have made the attempt, as it were, to fruit at low nodes by putting out abortive-fruited-branch buds. Occasionally, even the zone of undeveloped branches previously described is eliminated by the development of the fruiting-branch buds at every node.

REPRESENTATION OF BRANCHING HABITS BY DIAGRAMS.

By means of the accompanying series of diagrams (Pl. III), which are reproduced from exact copies of diagrams taken in the field, it has been possible to show the difference in the amount of fruiting on the primary fruiting branches of various strains of acclimatized



DIAGRAMS OF COTTON PLANTS OF THREE VARIETIES OF ACCLIMATIZED MIT AFIFI EGYPTIAN COTTON: A, SOMERTON VARIETY; B, YUMA VARIETY; C, SAGATON VARIETY. EACH SERIES REPRESENTS 10 PLANTS OF A SINGLE VARIETY TAKEN AS THEY CAME IN THE ROW. FOR A DISCUSSION OF THIS METHOD OF RECORD DIAGRAMS AND ITS POSSIBLE USES, SEE THE ACCOMPANYING TEXT, P. 16.

Egyptian cotton. Each series is composed of the diagrams of 10 plants of a single strain, taken as they came in the row.

Explanation of the diagrams.—The perpendicular line represents the axis of the plant; the letter *d* designates a dormant bud; large *V*, a large limb or vegetative branch; small *v*, a small limb. The letter *o* indicates a node of a fruiting branch bearing a boll; the letter *s* indicates a square or bud at a node of a fruiting branch, while a dash (—) represents a node of a fruiting branch from which the bud or the boll has been shed. The small *a* at the end of a series of these three last-mentioned characters means the abortion of the leaf bud and the termination of the growth of the branch, while the plus sign (+) signifies that the branch is still growing. The small *o* just at the right of the perpendicular and slightly above the line of the fruiting branch indicates fruits borne on fruiting branches in the axillary position. Occasionally two or more fruits are borne by such branches. A small *o* above and to the right of a character designating a node of the fruiting branch represents the fruit borne on a secondary branch in the axillary position at this node of the fruiting branch.

The signs were placed to the right of the axis to facilitate the work in the field. This plan has proved even more instructive than a diagram with successive branches placed alternately on the two sides of the axis, as the diagramming of all the branches on one side provides more ready means of comparison and shows more clearly the variation in determinateness of the fruiting branches. Each node of the axis is indicated by a character or series of characters at the right of the perpendicular line. Each fruiting branch is built of *o*'s and dashes (—), the number of nodes of a fruiting branch corresponding to the number of these characters in a series to the right of the perpendicular line. At the base of each plant the two opposite characters indicate the two nodes of the cotyledons, which are practically opposite and are counted as nodes 1 and 2 of the plant.

The general similarity between the shape of the diagrams in each series indicates the close relationship of the plants. Marked differences in a diagram, as in the case of plant No. 7 in series B, usually indicate diversity in many particulars. In this instance the bolls of plant No. 7 were small and the fiber was poor. Comparison of each series of 10 diagrams with the others affords a conception of the differences existing between strains, in height of first fruiting branch, number of fruiting nodes on fruiting branches, amount of fruit retained, involving the earliness of the strains, the number and size of the limbs, and the height of the plant. One inch of the perpendicular line represents approximately 1 foot 9 inches.

CHARACTERISTICS OF THE FRUITING HABITS OF DIFFERENT ACCLIMATIZED STRAINS OF EGYPTIAN COTTON SHOWN BY THE DIAGRAMS.

The space between the perpendicular line (axis) and a curve extending through the tips of the horizontal series of characters (fruiting branches) from near the base of the perpendicular to its apex represents the fruiting area provided by the fruiting branches of the main axis. The actual amount of fruit retained is shown by the frequency of the letter *o*. As the perpendiculars are all equidistant, the difference in the amount and contour of unoccupied space between the parallel perpendiculars shows most strikingly the individuality of each variety.

From the diagrams it can be seen that the Somerton variety puts out its fruiting branches at low nodes of the axis, but that a large proportion of the fruit is shed, the dashes appearing frequently. This variety also appears to have a less determinate growth than either of the other varieties and would be most prolific under cultivation that would permit the retention of all the bolls.

The Yuma variety retains a larger percentage of fruit than the Somerton variety, but it has a smaller fruiting area, mainly because of its shorter fruiting branches. This variety has a tendency to limit the length of its fruiting branches to six nodes, though plant No. 10 of the Yuma series, it will be seen, is an exception to this rule in that the fruiting branches are consistently seven nodes long. From the standpoint of crop production the Yuma variety has thus far proved the most promising. More extensive plantings of the other two varieties may prove them to be of equal or even greater value.

The Sacaton variety, as shown by the diagrams, behaves most consistently in putting out normal fruiting branches at nodes 11 and 12 and in retaining a large proportion of the fruit. The fruiting area is also larger than in the other two varieties, both on account of its longer fruiting branches and its habit of growth, which, like the Somerton, is less determinate than that of the Yuma variety. This selection yields heavier than either of the other varieties, but has been tested only in small plats.

The fruit production by secondary fruiting branches of the limbs has been disregarded in these diagrams. The similarity between the habits of the large limbs and axis, discussed later, is such that the retention of fruit on secondary fruiting branches of the limbs corresponds to that of the fruiting branches of the axis in each variety. Thus the large limbs do not influence the relative fruitfulness of a variety except as they are appreciably more numerous or fewer. As far as field conditions are concerned, a study of the main axis of the

plant answers all purposes, for closer planting, which will be practiced under field conditions, will equalize the total fruiting area of few-limbed and many-limbed plants by curtailing the growth of limbs.

APPLICATION OF DIAGRAMS IN BREEDING WORK.

Plant diagrams like those here used afford a simple means of recording graphically the fruiting habits of strains of cotton from year to year. They do not represent the comprehensive knowledge gained of each strain by study and comparison of many individuals throughout the year, but they do offer a means of representing graphically and statistically differences and similarities that exist among different varieties and different individuals within the same variety. Mistakes are also less common where the data are recorded graphically instead of in figures. If so desired, the material contained in the diagrams can be used to calculate correlations and statistical constants.

Kept through a series of years, these diagrams will equal in value as breeding records the more elaborate statistical methods of recording the expression of characters, for most of the data regarding vegetative behavior and fruiting habits are expressed in such diagrams. Records of this kind should be valuable in the study of the problems of heredity and variation, and if kept on a series of irrigation or cultural experiments they would provide useful data for determining the effect of different methods of culture.

PRODUCTION OF FRUIT ON SECONDARY FRUITING BRANCHES.

Under conditions of very luxuriant growth, as in most of the Arizona experiments, the fruiting branches of the main axis bear only about one-third of the fruit produced by the plant. The remainder of the fruit is borne by the secondary fruiting branches of the large limbs. On August 1, 1909, a count of 6,981 bolls on 52 plants in a block of acclimatized Egyptian cotton showed that only 36.6 per cent were borne on fruiting branches of the axis, the remaining 63.4 per cent being on the secondary fruiting branches. The fruit borne by these large branches develops considerably later than that of the main axis, usually producing the bulk of the second picking. The first fruiting-branch bud does not appear on the lower limbs before the sixth to eighth node of the limb, and often no secondary fruiting branch is retained until several nodes beyond this, as the early secondary fruiting branches may be abortive. Thus a similar mode of developing the fruiting branches occurs on both the main axis and the vegetative branches. The secondary fruiting branches are, as a rule, the only branches to develop on limbs; such secondary

limbs as do develop occur at the low nodes of the large limbs and remain dormant until the secondary fruiting branches have appeared. In this respect the limbs differ from the main axis.

Secondary fruiting branches appear at successively lower nodes on the limbs the higher the position of the latter on the axis. For instance, on the youngest limb of the plant in the zone of vegetative branches the first secondary fruiting branch may be borne at the fourth node, while on the oldest limb the first secondary branch is seldom developed before the tenth node. This is shown in graphic form in Table I. The data here presented represent the averages from 15 plants of each stock and were taken on mature plants at Somerton in the fall of 1909.

TABLE I.—*Nodes at which secondary fruiting branches arise on vegetative branches.*¹

Limbs.	Variety observed.			
	Yuma acclimatized.	Mit Afia Imported.		Jannovitch Imported.
		Ordinary type.	Infertile type.	
	Node.	Node.	Node.	Node.
1.....	10	10	16	10
2.....	8	8	15	8
3.....	8	6	19	8
4.....	7	6	12	7
5.....	6	6	11	6
6.....	6	6	10	6
7.....	5	5	11	5
8.....		4	10	

¹ These data represent averages from 15 plants of each stock.

In Table I, limb 1 represents the oldest (lowest) branch on the plant; limb 8 is the youngest (highest) limb in the zone of vegetative branches. It is evident that the younger limbs bear their secondary fruiting branches at successively lower nodes, so that limb 8 bears its first fruiting branch at node 4, though limb 1 does not retain a fruiting branch until node 10. The table further shows that acclimatized and unacclimatized (newly imported) stocks of Egyptian cotton bear fruiting branches at practically the same height on their corresponding limbs. The variability of fruiting branches of the main axis is considerable in the same stock and is still greater when imported and acclimatized stocks are compared. Selection for low fruiting branches of the axis gives more promise of results than does selection for low fruiting branches of the limbs.

On those axillary limbs which infrequently develop at the same nodes of the axis with the primary fruiting branches the arrangement of secondary fruiting branches, as observed on the large lower

limbs, does not hold. On the axillary limbs the normal secondary fruiting branches, instead of being borne at nodes near the axis, are deferred until very late nodes.

Rejection of fruiting-branch buds on the lower limbs appears to be a constant habit, the buds pushing out and then becoming atrophied at from two to six nodes below the first node at which a fruiting branch is retained.

The production of very late secondary fruiting branches is correlated with the slender erect habit of the infertile plants, which appeared rather infrequently in imported Mit Affi in 1909. Such a phenomenon may be an indication either of reversion or of hybridization. Some cases of unusual fertility may likewise be accounted marks of hybridization. Extreme fertility marks the early generations of a hybrid, while there is a tendency to sterility in later generations. On very fruitful hybrid plants the same ratio as in pure Egyptian types existed between the amount of fruit borne by the limbs and that borne by the main axis, about two-thirds of the total crop being found on the limbs.

INFLUENCE OF VEGETATIVE BRANCHES UPON THE SHAPE OF THE PLANT.

As shown in the preceding discussion there is variation in the position and degree of development of the fruiting branches. Though this is often well marked, it is not the most conspicuous kind of variation in the branches. Variations in the limbs have more effect upon the shape of the plant. The number of large limbs, their length, and the angle which they form with the main axis are all factors that determine whether the plant is of a bushy shape or is strictly erect, with a prominent leading axis.

It sometimes occurs that the limbs are not developed at all, in which case the plant is a single stalk with horizontal or drooping fruiting branches. This limbless condition is not frequent. Indeed, plants are more often found with the limbs so strongly developed that it is difficult to distinguish the main axis among them. The extent to which a limb may take the place of the main axis has been observed in plants that have been topped just above the fourth or fifth node, thus forcing the development of the lower limbs. In plants that mature after such pruning the limb from the last node below the severed axis has taken on the functions and appearance of the main axis so completely that the shape of the matured plant is perfectly normal and the abnormality can be distinguished only by the closest inspection. It sometimes appears, even in unpruned plants, that the limbs have usurped the leading functions of the axis, and have appropriated the nourishment to themselves, leaving the axis weak, while they are robust and of large diameter.

A common type in newly imported stocks of Mit Affi grown in 1909 was a strict, upright plant, with more or less rigid axis and limbs ascending at sharp angles, so close to and so nearly parallel with the axis that the fruiting branches of the main axis occasionally extended beyond the limbs.

Plants bearing more numerous low limbs are necessarily of greater diameter and more bushy; the lowest limbs arise from the axis at broad angles and extend out farther from the axis than the upper branches. The limbs usually reach nearly the height of the main axis, unless they are weighted down with fruit, in which case they spread more widely and leave the axis free and overtopping them. The latter is the condition in the most fruitful acclimatized stocks. Again, the limbs of some plants are short, a condition likewise observed in hybrids in 1908, and do not become a factor of normal importance in the productiveness of the plant, the main axis having acquired nearly as much prominence as in the "limbless" condition referred to. Such diversities occur most frequently in newly imported stocks. In selected acclimatized stocks more uniformity of type is apparent, though diversities still exist. In general, what appears to be the most promising type of branching in Egyptian cotton is represented by plants of the Yuma stock. These plants are from 6 to 8 feet tall, with a leading axis, five or six limbs nearly as long as the main stem but loaded with fruit, and consequently spreading at an angle of from 50° to 60° , and above them on the axis pendent fruiting branches—a plant of symmetrical, broad-spreading, inverted kite shape.

Much of the diversity in branching and in form of plant in the unacclimatized stocks of Egyptian cotton may have to be ascribed to hybridity or to reversion toward the Hindi cotton, as the indications now are that contamination exists in all Egyptian varieties, in some to a much more marked degree than in others.¹

EFFECTS OF PRUNING ON BRANCH DEVELOPMENT.

The "topping" of cotton plants has been advocated as a means of hastening the maturing of fruit, but it has never gained a place in cotton culture. It is not known that an extensive and conclusive set of tests has ever been made, though cases of whole plantings being topped have been reported.² Its possibilities as a practical method of increasing yields have not yet been ascertained in this country,

¹ Cook, O. F. Hindi Cotton in Egypt. Bulletin 210, Bureau of Plant Industry, U. S. Dept. of Agriculture. 1911.

² "It was at one time common with some growers to cut off the growing top of the cotton plant after the bolls were formed. By doing so, they maintained, the quantity of fiber was increased and its quality improved. The practice has now practically died out." See Foaden, G. P., "Cotton Culture in Egypt," Bulletin 42, Office of Experiment Stations, U. S. Dept. of Agriculture, 1897, p. 21.

but it is sometimes advocated as a means of encouraging earliness and fruitfulness. The method should be tested, especially in the case of Egyptian cotton, which matures late and takes on a rank vegetative growth on fertile, well-watered soils of the lower Colorado River region in Arizona and California.

Preliminary experimentation and observation by the writer have thrown some light on the effect of topping or pruning on habits of branching, though the most conspicuous effect was to accelerate vegetable growth. When the growing tip of the axis was removed the branches at a node or two below grew more vigorously than usual and the uppermost branch, whether fruiting or vegetative, showed marked tendency to assume an upright position. When a large limb was cut back to near the point of union with the main axis the lowest bud of the severed limb or a bud at the node of the stem from which it originated grew rapidly to replace the branch removed. In the case of fruiting branches the growth was somewhat hastened, the branch became thick and rigid, and the bracts very large and coarse. Many instances of abortion of the growing tip of the main axis occur, a natural pruning, with a similar result in causing the fruiting branches to take on a resemblance to vegetative branches.

In general, it may be said that the result of pruning 40 plants at different levels of both axis and branches has been the acceleration of growth in branches just below the point of pruning. In none of these cases was it apparent that fruitfulness was increased or that the fruit already set was matured more rapidly or opened earlier than on neighboring unpruned plants. Another effect of topping the main stem was the forcing into growth of the buds on that portion of the stem referred to as the "zone of undeveloped branches," which buds remain dormant under normal conditions.

There has been no topping of nearly mature plants to test the effect upon earliness, but it is practically demonstrated that there is no advantage in pruning young plants, as the ripening of the crop is only retarded by such a practice.

The buds at nodes of cotyledons may be forced into growth by cutting back young plants. As already recorded, buds in the axils of cotyledons normally develop in only a small proportion of plants. Series of young plants were topped below the first, second, and third true leaves. In plants pruned below the first true leaf, which left only the buds in the axils of the cotyledons, these buds developed rapidly. In plants that were topped above the third or fourth node the bud at the node next below the point of pruning usually developed most rapidly and soon took on the upright nature of the axis. Where only branches from nodes of the cotyledons were left these developed

to form a plant in superficial appearance not unlike one of normal growth. In such instances, and in many others when rabbits pruned back the young plants below the first true leaf, the production of fruit was somewhat later than in normal plants.

BRANCH DIVERSITY IN RELATION TO ENVIRONMENT.

In several instances variations in growth and branching appeared which could be ascribed to environment. The most marked of these was the variation in length of the first internode of fruiting branches, previously referred to. In a small planting of Egyptian cotton at Los Angeles, Cal., the first internode of the fruiting branches was invariably longer than in the Egyptian cotton grown elsewhere in the Southwest, frequently attaining 11 to 18 inches. The usual length of the first internode of fruiting branches in Egyptian cotton grown at Somerton and Sacaton, Ariz., was 6 to 8 inches, an inch or two longer than the leafstalk at the same node. The leafstalks at Los Angeles were rather shorter than in Arizona, so that the first internode of the fruiting branches often was more than double the length of the petiole. The remarkable association of abbreviated leaf petioles with elongated internodes of fruiting branches was common to both imported and acclimatized stocks of Egyptian cotton at Los Angeles. Besides these varieties, which grew to a height of 7 to 9 feet in Arizona, never exceeded $5\frac{1}{2}$ feet in this planting and the limbs were less numerous and comparatively short, seldom reaching a length equaling two-thirds that of the main axis. The only differences in vegetative characters between the two stocks at Los Angeles were the slightly lighter green foliage of plants of the imported stock and the greater percentage in the same stock of plants bearing small bolls. This peculiar response of the plants to the Los Angeles conditions was remarkably constant.

As a rule there are from five to ten more internodes in the stem than in the largest limb. There is a tendency to a smaller development of the limbs in locations of restricted moisture than where the moisture supply is more abundant and constant. In the latter locations the largest limb may closely approximate the axis in number of the internodes.

Egyptian cotton plants growing in soil containing considerable quantities of alkali had fruiting branches postponed and vegetative branches restricted. At Sacaton, Ariz., in 1910, fruiting branches appeared at the thirteenth node on the Yuma variety of plants growing on soil free from alkali. On plants growing on alkali soil fruiting branches were not put out until the sixteenth node, and five limbs developed as compared with seven on plants growing on soils without alkali.

From observations on the plantings of Egyptian cotton at several stations in California and Arizona in 1910 it is clear that the various conditions under which the cottons were grown occasioned marked differences in the height on the stem at which fruiting branches first developed. The Yuma variety of cotton bore its first fruiting branch at node 9 (average) at Stockdale, Cal., and at node 13 at Red Bluff, Cal.; under other conditions the same variety did not fruit below node 14. The results of these observations are given in Table II.

TABLE II.—Differences in the average number of limbs and the average number of nodes below the first fruiting branch in several plantings of Egyptian cotton in the season of 1910.

Localities.	Variety observed.			
	Yuma (acclima- tized).	Mit Afifi (unaccli- matized).	Yuma (acclima- tized).	Mit Afifi (unaccli- matized).
	<i>Limbs.</i>	<i>Limbs.</i>	<i>Nodes.</i>	<i>Nodes.</i>
Sacaton, Ariz. (1).....	6.4		12.6	
Do. (2).....	4.8		15	
Yuma, Ariz.	6.5	8.6	11	14.4
Chico, Cal.			11.1	12.1
Glendale, Cal.			8.2	9.3
Red Bluff, Cal.	4	4	11.8	
Semitrpic, Cal.			8.7	10.4
Stockdale, Cal.	4.2	5	8	9.5
Vinalia, Cal.			11.4	12.6
Falfurrias, Tex.			12.8	

In the accompanying table the comparisons between Yuma (acclimatized) and Mit Afifi (unacclimatized) Egyptian cottons were made in parallel rows, except at Yuma, where the conditions of soil and culture were different for each stock. Some superiority is displayed by the Yuma cotton in producing fruiting branches at slightly lower nodes than the newly imported Mit Afifi cotton. At all stations excepting Falfurrias, Tex., irrigation was practiced. The second record of the Yuma variety at Sacaton indicates the effect of alkali soil in delaying the fruiting branches to node 16 and in restricting the limbs to five to the plant. Another condition of delayed fruiting branches caused by excessive vegetative growth, exemplified in Mit Afifi grown at Yuma in 1910, is accompanied by a normally increased number of limbs. The necessity of determining the cultural requirements of low fruiting is emphasized by the occurrence of such differences within the variety. The stimulation of the plants to retain and nourish fruiting branches which are aborted or fail to develop under less favorable conditions is to be expected with confidence from improved cultural methods.

EFFECTS OF LATE PLANTING ON HABITS OF BRANCHING.

Late planting, as far as has been observed, seems to accelerate the development of limbs and to delay the growth of fruiting branches. This may be only an expression of more exuberant growth, since

late-planted cotton in Arizona in 1909 did not suffer the retarding influence of cool nights which the early planted (Mar. 15-20) cotton experienced. The deferred appearance of fruiting branches in late-planted cotton would not only mean a relatively later crop, but might also result in lessened fertility, as compared with early planted cotton which put out fruiting branches lower down. Late plantings of a stock of Egyptian cotton which has been grown at Sacaton, Ariz., for several years produced its first fruiting branch at node 17 (average), which was three nodes higher (later) on the plant than the first fruiting branches produced on plants alongside, grown from seed of the same stock but planted a month earlier (Mar. 22). The late plants also bore two more limbs to the plant than the earlier plants.

ABNORMAL VEGETATIVE GROWTH ON PROSTRATE PLANTS.

Plants of the most uniform acclimatized stock (Yuma) in many instances were prostrated by their own weight or blown over by storms. In such cases one of the limbs assumed an upright position and outgrew the central stalk. It was usual to find such branches with more nodes than the axis. Another effect of the prostrating of plants was the long vinelike growth of the ends of branches when their growing tips were shaded beneath dense foliage. The internodes grew to much greater length than normally, so that the end of the branch resembled a long slender whiplash. When limbs are partly broken off, secondary limbs develop at practically all of their nodes, though under normal conditions they remain dormant, especially at the lower nodes. Where several limbs are prostrate, these branches send up very numerous sprouts close together, forming veritable thickets.

BRANCHING HABITS OF THE DIFFERENT EGYPTIAN VARIETIES.

Diversity due to hybridization or reversion is so great in some of the Egyptian varieties grown in Arizona from imported seed that it is difficult to fix upon any marked constant difference between the varieties. Furthermore, the differences in soil and cultural conditions in the fields in which the several varieties were grown affected the habits of the plants to an extent which made direct comparison difficult. However, some differences appear.

Jannovitch cotton plants are more open than Mit Affi, bearing fewer limbs, a condition which may account for the lighter yield of the Jannovitch. Both varieties grew to a height of 7 to 8 feet, but the Jannovitch took on a more spreading habit than the Mit Affi. In the Jannovitch field the plants with their heavy, wide-spreading limbs were considerably broken down, while the Mit Affi plants in another field remained for the most part erect. The Mit Affi stock

also contained many plants that showed tendencies to abort their lower fruiting branches. This semisterile condition may be an indication of hybrid contamination, although these effects might have been induced to some degree by different conditions of soil and cultivation. Nubari plants were more nearly like the best acclimatized stock in bearing fruiting branches at lower nodes on the stem than either the Jannovitch or Mit Afifi varieties as grown from imported seed, which made the Nubari comparatively more fruitful than the other imported varieties. In contrast to the erect habit of Mit Afifi and the more open habit of Jannovitch, some of the Ashmuni plants were low and bushy, producing more limbs. But this stock was so completely diverse that it was practically impossible to distinguish a typical form.

CONCLUSIONS.

The Egyptian cotton plant bears two kinds of branches, long vegetative branches on the lower part of the stem, which bear no flower buds directly, and above these, to the top of the plant, shorter fruiting branches which bear flower buds.

The differences between vegetative branches and fruiting branches are very sharp: (1) Vegetative branches usually approximate the length of the main stem, while fruiting branches are about one-third as long. (2) Vegetative branches bear no flower buds except as they produce secondary fruiting branches. Fruiting branches bear a flower bud at each node opposite the leaf. (3) The vegetative branches, like the axis, bear fruiting branches and may bear vegetative branches. The fruiting branches rarely bear fruiting branches or vegetative branches.

Vegetative branches may be either axillary or extra-axillary. Normal fruiting branches are always extra-axillary. Single bolls or short fruiting branches are sometimes developed from buds in the axillary position, at nodes bearing fruiting branches. Such branches may be regarded as secondary fruiting branches borne by the axillary vegetative branch, which is itself suppressed.

From 6 to 8 large vegetative branches are usually produced from the first 10 nodes of the axis. At the next 2 or 3 nodes the buds frequently remain dormant or are abortive, and above these a fruiting branch is produced at each node.

Under conditions of great luxuriance extra-axillary limbs occur at some of the lower nodes which would bear fruiting branches if the development of limbs was restricted.

The length and number of vegetative branches largely determine whether the plants are bushy and spreading or upright. The control of the production of vegetative branches—that is, of the stature

of the plant—is necessary because of the desirability of small plants in cultivation and harvesting.

Egyptian cotton when planted late apparently develops more numerous vegetative branches than when planted early. Early planting is therefore advisable as a means of restricting the development of vegetative branches.

Abortion of early fruiting branches on both axis and large limbs is common in a greater or less degree to all stocks grown from imported seed. Even the Arizona acclimatized plants frequently abort their lowest fruiting branches.

Some of the selected acclimatized types of Egyptian cotton originated in the United States bear fruiting branches at lower nodes on the stem than the stocks of imported Egyptian cotton. Selection for low fruiting gives promise of being a practical means of increasing earliness and yield.

Of the six Egyptian varieties grown in Arizona in 1909 from imported seed, Nubari most nearly resembled the acclimatized stocks in putting out fruiting branches at comparatively low nodes of the stem.

A method of recording branching habits of cotton by means of diagrams has been devised. The diagrams show the location of branches, the development of fruiting branches, and the stature of plants. Such diagrams promise to be of value as records in the cultural and breeding study of cotton. (See pp. 16–17.)

Preliminary experiments in “topping” young plants have resulted in stimulating the growth of buds in the axils of cotyledons. Branches just below the point where the plant is topped make an excessive vegetative growth and tend to assume an upright position in place of the severed axis. The topping of nearly mature plants to hasten the ripening of fruit has not yet been adequately tested.

Egyptian cotton plants grown on soil containing considerable alkali restrict the development of limbs and reject their early fruiting branches.

Differences in the branching habits of the different Egyptian varieties grown from imported seed are not sharply defined because of the diversity within each variety and hence can not at present be used to distinguish one variety from another.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 250.

B. T. GALLOWAY, *Chief of Bureau.*

THE DISEASES OF GINSENG AND THEIR CONTROL.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., March 8, 1912.

SIR: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 250 of the series of this Bureau a manuscript entitled "The Diseases of Ginseng and Their Control," by Prof. H. H. Whetzel, Plant Pathologist, Cornell University Agricultural Experiment Station, and Collaborator, Bureau of Plant Industry, and Mr. Joseph Rosenbaum, Special Agent, Bureau of Plant Industry.

Ginseng culture is actively pursued in many States and the growers have encountered an increasing number of diseases of late, thus creating a marked need and an active demand for information on the methods of control. To meet this need without duplication of effort and expenditure the Bureau of Plant Industry has arranged for the extension of the investigations in New York to other States and for the publication of the results for general distribution.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

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THE DISEASES OF GINSENG AND THEIR CONTROL.

INTRODUCTION.

This bulletin represents the second attempt to bring together in concise form the knowledge of the diseases of the drug plant *Panax quinquefolium* L., commonly known as ginseng. The first publication of this nature was that by Van Hook¹ in 1904. Since that time there has accumulated a considerable body of new knowledge relative to the maladies of this crop, but more or less scattered in various bulletins and other publications. While further investigation of many of the diseases herein discussed is still needed, it is believed that the facts and conclusions presented in these pages represent our best knowledge of these to date.

Before taking up the discussion of specific diseases it seems desirable to point out some general considerations with respect to this crop which appear to have special significance as regards the diseases affecting it. Ginseng has but recently been brought under cultivation in this country. Twenty years doubtless cover all attempts at cultivation of any consequence in America. A closely related species has been cultivated for at least 200 years in Chosen (Korea) and Japan.

Ginseng is a native of the North Temperate Zone, finding most congenial conditions on woody hillsides and ravines covered with deciduous trees. This habitat indicates three factors favorable to its growth, i. e., shade, good soil drainage, and soil acidity. The failure of the grower to take all these factors into consideration when removing the ginseng from its natural habitat to his gardens has been primarily responsible for most of his losses. The necessity of shade was so evident that pioneer growers, almost without exception, took the hint and the shading of the beds has gone far toward perfection at the present time.

Not recognizing the tree roots of the forest as important factors in the drainage of the forest soils, the grower has seldom made the necessary tile drainage in his beds, depending usually upon the slope of the land to carry off excess rainfall. A frequent result has been heavy losses from root rots.

¹ Van Hook, J. M. Diseases of Ginseng. Bulletin 219, New York (Cornell) Agricultural Experiment Station, 1904, pp. 163-186.

With little thought as to the chemical character of the forest soil to which the ginseng roots are accustomed he has made heavy applications of wood ashes or lime, bringing about an alkaline condition of his soil where an acid condition is required. The result has been an almost universal epidemic of the rust or fiber-rot caused by a fungus especially favored by an alkaline condition of the soil.

Another factor rarely considered by the grower, but one having a direct bearing upon the prevalence of disease among the plants, is crowding. In the forest the plants occur singly or in small colonies more or less widely separated from each other and protected from the contagious diseases of their neighbors by distance, tree trunks, and thickets and by the usual quiet air of the heavy forest depths. When brought under cultivation they are crowded together, touching each other on every hand. The old and diseased as well as the young and healthy roots are planted together side by side. There is nothing to prevent the ready spread of the spores or germs of any disease from one plant to another; hence, epidemics of *Alternaria* blight, *Phytophthora* mildew, etc., have occurred. Observations indicate that the cultivation of ginseng in small gardens will usually prove most profitable in the long run, but more space for each plant seems desirable.

In the following discussion the diseases described have been grouped under four types readily recognized by the grower, i. e., blights, wilts, galls, and rots. No attention has been paid to the cause of the disease in this classification. They are for the most part due to attacks of parasitic fungi. Nematode worms are responsible for the gall disease reported and the soft-rot appears to be due to the invasion of certain bacteria. Physiological derangements due to drought and the like appear to cause the papery leaf-spot.

Insect injuries, while occasionally occurring, are of too little importance to warrant description. Millipedes and snails often eat into the roots of young stems of the plants, but no very effective means of preventing this appears to be known. Moles occasionally cause injury by loosening the soil so as to cause a wilting of the plants and are believed by some growers to eat the roots at times. Traps appear to be the most effective means of combating this pest.

The data presented on each disease have been arranged under the four heads of History, Symptoms, Cause, and Control as representing those phases of most direct interest to the growers. Only such technical matter has been introduced as is deemed necessary for a clear understanding of the other facts presented.

SPECIFIC DISEASES OF GINSENG.

BLIGHTS.

ALTERNARIA BLIGHT.

Alternaria blight is the most common, widespread, and best known of the diseases of ginseng. Nevertheless, isolated gardens here and there appear to have thus far escaped the malady, though each growing season brings reports of the disease from new localities and every grower must expect sooner or later to meet this enemy of his crop. His success in combating the disease will depend more upon his accurate knowledge of the disease and the methods of controlling it than upon his peculiar location, the character of his soil, special methods of shading, etc. Notwithstanding the very general occurrence of this blight in all the ginseng-growing sections of the country and the repeated published descriptions of the disease, accompanied with suggestions for its control, many growers appear to be unacquainted with its symptoms, the nature of the fungus causing it, and the proper use of fungicides in combating the parasite.

History.—Just when the *Alternaria* blight first appeared in ginseng gardens can not be determined. Doubtless it has been present in some gardens since they were first planted. It is certain that the disease is a natural malady of the wild ginseng plant. The natural antipathy of the grower in the early days of the cultivation of this crop against admitting the presence of any disease in his stock, which was to be sold largely for planting new gardens, doubtless prevented to some extent the prompt reporting of this disease when it first appeared. It does not seem probable, however, that the disease was very common or destructive prior to 1904. Van Hook,¹ who first studied the diseases of ginseng, does not mention this disease in his bulletin published in the spring of 1904. The *Alternaria* leaf-spot described by him on pages 163 to 184 and shown in figures 39 and 40 is certainly not the disease now commonly known as *Alternaria* blight. Neither the spots nor the fungus figured are the same as the disease described herein. Had the blight been as common and destructive during 1902 and 1903 as it has been since that time Van Hook would certainly have observed it in some of his travels about the State of New York. For this reason the writers are inclined to the opinion that the very serious outbreaks of the disease in different gardens in 1904 mark the beginning of the history of this blight as a serious pest of cultivated ginseng.

During succeeding years the *Alternaria* blight has made its appearance in gardens all over the ginseng-growing regions of the United States and Canada. We have specimens and reports of the ravages

¹ Van Hook, J. M. Diseases of Ginseng. Bulletin 219, New York (Cornell) Agricultural Experiment Station, June, 1904, pp. 163-184.

of the malady from as far west as Wisconsin and Kansas, south to Virginia, the Carolinas, and Tennessee, east to the Atlantic Ocean, and north to Michigan and Canada. This almost universal distribution of the disease is to be explained, in the writers' opinion, by the fact that it is a natural malady of the wild plant.

That the fungus causing the disease has been carried from garden to garden by visitors, the spores clinging to their clothing, seems more than probable. This would explain the very general dissemination of the parasite in a given locality or region. It will, however, hardly account for the appearance of the disease in widely separated regions or in isolated gardens far from the main centers of ginseng cultivation. It would seem but reasonable to hold that the fungus had found its way originally into each region or into isolated gardens on the wild plants that served as the original stock.

The history of the disease has been that where once established in a garden its complete eradication is quite out of the question. As long as thorough and systematic control measures are applied the disease may be held in check and its ravages reduced to a minimum. In some seasons weather conditions unfavorable to the fungus may serve to lead the grower into the notion that the disease has disappeared. The recurrence of favorable weather, however, soon disillusions him, and he finds his plants again going down before the onslaughts of the blight. The grower who has had one lesson should never need another. The grower who has never experienced a blight epidemic should equip himself to meet it; otherwise he will eventually suffer the consequences. (Pl. I, fig. 1.)

While the disease is certain to appear and disaster to follow if neglected, it can be controlled. The cause of the disease has been definitely demonstrated. A method of control has been worked out and repeatedly shown to be effective. The wise grower will accept proved facts and methods, will inform himself as to the nature and habits of the blight fungus, and will not be led astray by absurd theories and superstitious beliefs as to the nature of the disease and its control.

Symptoms.—Contrary to the common opinion of the growers, the first symptoms of the disease are to be observed on the stems of the plants (Pl. II, fig. 1) instead of on the leaves (Pl. I, fig. 2).

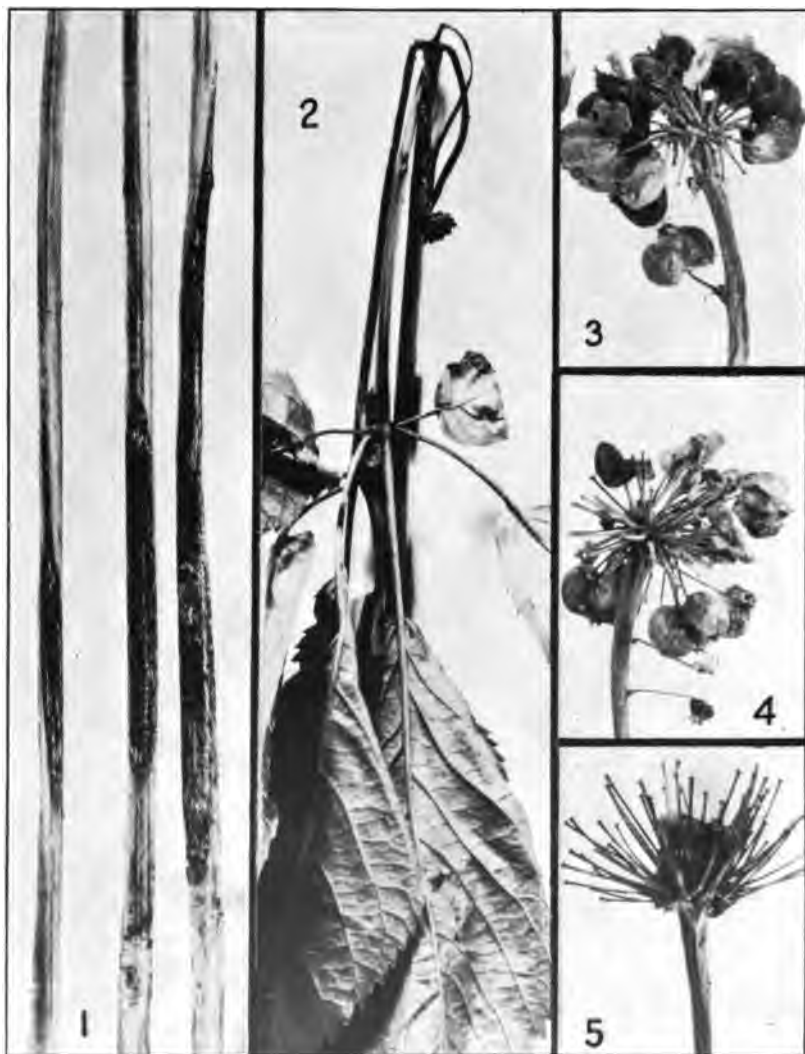
After the plants are well up, a careful inspection of the gardens, especially where the blight was present the year before, will often reveal diseased stems here and there in the beds. These show dark-brown spots of some length on one side, usually just above the surface of the ground. (Pl. II, fig. 1.) Affected stems usually are not numerous and unless especially sought will be overlooked. The grower occasionally discovers these diseased stems, for they sometimes become so seriously affected that they rot off and break over. While



FIG. 1.—BED OF GINSENG PLANTS, SHOWING THE RESULT OF AN EPIDEMIC CAUSED BY ALTERNARIA BLIGHT.



FIG. 2.—LEAVES OF GINSENG, SHOWING ALTERNARIA LEAF-SPOT.



PARTS OF GINSENG PLANTS ATTACKED BY ALTERNARIA.

[Fig. 1.—Stems with dark-brown lesions. Fig. 2.—Plant attacked at base of leafstalks.
Figs. 3, 4, and 5.—Seed heads.]

they seldom become numerous enough in a garden to cause serious loss from this trouble alone, they serve for the production of millions of the spores of the fungus which, scattered through the gardens, produce later the too well-known blighted leaves and tops.

The symptoms of the disease on the leaves are quite characteristic and generally well known. Spots of varying size, usually half an inch or more in diameter, appear on the leaves. (Pl. I, fig. 2.) At first water soaked, they gradually dry out, leaving a light papery center with a rather broad, rusty brown border. The spot may gradually spread and, uniting with other spots, involve the entire leaflet. The disease may also attack the tops at the point where the leaflets are attached to the leafstalks (Pl. III, fig. 1) or where these leafstalks arise at the top of the stem. (Pl. II, fig. 2.) The drooping of the leaflets from the end of the leafstalk and the drooping of the leafstalks from the top of the stem are symptoms also characteristic of mildew, but are readily distinguished from that disease by the velvety brown color of the stem and leafstalks at the point of attack. This velvety brown appearance of the parts affected with the *Alternaria* blight is due to the multitude of spores of the fungus covering the disease lesions.

The seed heads also are commonly affected. The green half-grown berries show brown, discolored spots; the little stem bearing the berry becomes brown and shrivels and the blasted berry falls. (Pl. II, figs. 3, 4, and 5.) This shelling of the berries, which may occur any time up to ripening, is often a puzzle to the grower.

There is so far no evidence that the disease ever directly attacks the roots of the plant. It is distinctly an aboveground disease. It affects the root indirectly by killing the tops and thus stunting or preventing further root growth. Roots of plants that have blighted badly one season appear never fully to recover from the shock, and even though their tops are protected from the disease the following seasons they never compare favorably with plants of the same age which have not suffered from the blight.

Cause. —The blight is caused by a fungus (*Alternaria panax* Whetzel), a minute parasitic plant that lives and grows within the tissues of the leaves, stems, and berries of the ginseng plant. It pushes its rootlike mycelium through the leaf or stem tissues of the ginseng, killing the living substances of the host and appropriating the foods and juices thus made available. From this mycelium it sends forth, to the outside, clusters of short, brown stalks, on the ends of which are produced the seedlike spores (fig. 1), singly or in short chains of two or more. Both the mycelium and the spores are very minute and can be distinguished only by the aid of a microscope. The spores are dark brown in color, with cross walls in both directions dividing

them into a number of small chambers or cells. Each cell of the spore is capable of germination, sending forth, when placed for an hour or so in water, a long sprout or germ tube (fig. 2). These germ tubes, if the spores be on a ginseng leaf or stem, penetrate the epidermis of the host and push through the tissues within, branching and forming the mycelium above described. It is only into the ginseng plant, however, that this germ tube is able to penetrate and develop, and this fungus is therefore never found causing a blight of other plants.

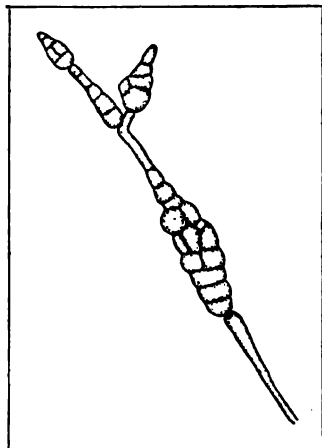


FIG. 1.—Chain of spores of *Alternaria panax* on the end of a spore stalk.

Alternaria panax is able to live as a parasite only upon the ginseng plant, and the very common opinion among growers that this fungus lives on weeds, potatoes, etc., and spreads from these to the ginseng is without any foundation in fact, so far as known. That this fungus is the genuine and only cause of the disease has been repeatedly proved by inoculations, that is, by placing spores of the *Alternaria* on the leaves and stems of healthy plants. The disease invariably appears in 4 to 10 days. That this fungus will not affect the potato, for example, has been shown by repeated failures to produce diseased spots by inoculating healthy potato leaves with the spores of the fungus.

The manner in which the spores of the fungus first find their way into the gardens varies in different cases. Often the parasite doubtless has been brought in with wild plants from the woods, as it has been observed on ginseng plants in the woods. Sometimes it seems quite certain that the spores have been carried from diseased gardens to healthy ones on the clothes of persons visiting the gardens. That the fungus may be introduced with seed into a new garden is possible, but judging from careful observations extending over several years this is, to say the least, not at all common. We have never observed a single case of blight that could in any way be attributed to diseased seed. Furthermore, the disease is not at all common on seedlings, attacking them only under favorable conditions, when

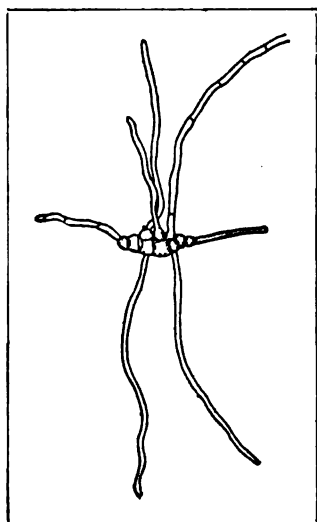


FIG. 2.—Germinating spore of *Alternaria panax*.

there is an epidemic of the disease in older plants in adjoining beds. Other diseases of the seedlings are frequently confused with blight.

Having once been introduced into the gardens the seasonal habits of the parasite are as follows: The fungus passes the winter in old, dead, diseased stems of the previous season, the mycelium remaining alive but dormant in these old stems, much as the roots of the ginseng lie dormant in the soil. In the spring, when conditions become more favorable for the growth of the dormant ginseng roots and they begin to send up their stalks, the mycelium in the old stems also starts into growth, sending up new spore stalks on which a new crop of spores is quickly produced. We have observed this production of spores and have produced the disease in healthy plants by inoculation with them. It is quite possible that under favorable conditions the spores produced in the summer or fall may also pass the winter in a viable condition. They have been freely germinated when placed in water after having been kept dry in the laboratory for over three months. On the other hand, on the soil in the beds most of the spores produced through the summer probably germinate and die before winter. The new crop of spores produced from the mycelium in the old stems in the spring is doubtless the chief source of the first or primary infections.

The primary infections appear, as already described, on growing stems just above the surface of the ground. It is common to find a diseased stalk with the old stem still standing up beside it or lying at its base. It has been found easy to infect the new stalk as it comes through the ground with spores produced on the old stems. The fungus grows rather slowly on the stalk, so that the tops are usually well expanded before the spot has reached a size sufficient to attract attention. These spots on the stalk soon become covered with a velvety brown coat of spores, which are produced from the ends of the spore stalks that grow out from the mycelium in the diseased tissues. When these spores are ripe they break away from the spore stalks very readily and are carried through the garden by the slightest breeze. In this way they reach the leaves, falling upon the upper surface or into the crotches formed by the base of the leaflets or by the leaf stems at the top of the stalk. Here they lie inactive until a rain or heavy dew ensues. They then germinate and infect the leaf or leaf stems, as already described. Another crop of spores is now formed, especially on the diseased leaf stems. Spores are not usually produced abundantly on the spots on the leaves. This second crop of spores serves to infect the seed heads, causing the shelling of the berries. Spores are usually produced in great numbers on the diseased seed stalks and shriveled berries.

Many parasitic fungi pass the winter by means of a different kind of spore than that which is produced to spread the parasite through

the summer. This does not appear to be the habit of *Alternaria panax*, at least we have thus far never observed any winter spore form. The fungus apparently passes the winter as hibernating mycelium in the old, dead, diseased stems. The fungus is thus accounted for throughout the year. With these facts before us it should now be less difficult to understand its sudden appearance in the ginseng garden and the relation of weather, etc., to epidemics of the disease.

Ecology of the disease.—By ecology is here meant the relation of weather, location, shade, soil, mulch, etc., to the appearance and severity of the disease. It is a too common belief of growers that weather, soil, or some improper fertilizer is the direct cause of diseases in their crops. This is seldom true, certainly not in the case of *Alternaria* blight. These external factors, especially the weather, do influence to a marked extent the severity of the malady. The spores of the fungus not only require moisture in which to germinate, but that moisture must continue long enough on the leaves or stems so that the tender germ tubes may have time to penetrate the host plant and become established as mycelium in the tissues.

Just how much time is ordinarily required for this growth is not known, but experiments indicate that probably not less than 24 hours of cloudy, rainy weather or heavy dew are necessary. It requires from four to nine days for the diseased spots to make their appearance after infection. Cloudy, rainy weather is favorable to the rapid development of the spots after the fungus is established within the tissues. Heavy showers of short duration followed by bright sunny weather are not especially favorable to the blight. It is the cloudy, rainy periods continuing for a day or so that favor an epidemic of this disease.

The relation of temperature to the development of the disease has not been worked out. Growers generally hold that hot weather brings blight. It is true that the malady seems to develop most destructively during the hot months of July and August, but only when there is sufficient moisture. The seasons of 1907, 1908, and 1909 were generally hot and dry, and except in localities where there was a rainy period *Alternaria* blight caused relatively little loss. As is the case with many other parasitic fungi, it is quite possible that a drop in temperature accompanying a rainy period during the hot season is favorable to infection by *Alternaria panax*.

There has been much discussion by growers as to the relation of different types and amounts of shading to the blight. By some the question of mulch has been regarded as a controlling factor. We must confess that none of these theories appear to have any basis in fact. Our observations extending over a period of six years and a careful consideration of the data presented by growers convince us that shade and mulch have very little to do with the appearance and

severity of this disease in a garden. Location may play some part, though much less than is usually attributed to it. A garden so situated as to have good air drainage or ventilation may escape the disease to some extent, or occasionally, because the plants dry off more quickly, but the grower who depends upon his location instead of his sprayer for the control of the blight is doomed to lose sooner or later. The type of soil or kind of fertilizer used appears to be unimportant in regard to their relation to this disease.

Any of these factors—heat, shade, mulch, soil, fertilizer, etc.—is apt to be hit upon by the grower as a source of his misfortune when disease takes his crop, because of his lack of knowledge of the true nature of the malady, its causal organism, and the relation of external conditions to its development. Two factors appear to be of prime importance in the case of this disease: (1) The presence of the causal organism (*Alternaria panax*) and (2) the proper conditions as to moisture for its development.

Control.—While very satisfactory progress has been made in the control of this malady, there still remains much to be done in working out the details and perfecting the methods and means now employed for combating it.

The various means now employed in the control of the *Alternaria* blight are based upon one of three of the fundamental principles of plant-disease control and may be discussed as follows:

In most cases it is now too late to take measures to prevent the introduction of the fungus into the garden. It has already become established. In some gardens, more or less isolated, the disease has not yet appeared. In view of the strong probability that spores of the fungus are frequently carried from diseased gardens on the clothing of visitors it is highly important that growers having gardens that have never shown blight should exercise the greatest care in admitting persons to their inclosures. Neither the owner, workmen, or visitors should enter the garden in clothing, shoes included, which has recently been worn in gardens affected with the disease. Since the spores of the parasite retain their vitality for a long period, thorough brushing or even sterilization of the clothing after a visit to a disease-infested garden is imperative. The introduction of the fungus into new plantings with seed or roots is possible, but the evidence at hand indicates that this is not frequent.

Since the fungus is a natural enemy of the wild ginseng plant it may be easily introduced on diseased plants transplanted (top and all) from the woods. From the nature of the parasite it seems very probable that the fungus, if introduced with seed or roots, will be in bits of diseased stems or leaves mixed with the soil in which roots or seed are packed. Such soil should be so disposed of as to prevent its introduction into the new gardens. To guard against possible

spores or bits of infected stems getting into the soil with seed or roots, these may be dipped before planting for 10 or 15 minutes in a formalin solution, 2 parts in 100 parts of water. It must not be expected, however, that such measures will absolutely insure against the appearance of the fungus, and the ease with which it is carried from garden to garden makes certain its introduction sooner or later into even the most carefully guarded plantings. Other measures, which will be described later, must also be employed if losses from this pest are to be avoided.

The eradication of the fungus after it once becomes established in the garden is practically impossible. Sanitary measures, such as the removal and destruction of the diseased tops, the burning over of the beds in autumn, or the spraying of the surface with a strong copper sulphate solution will doubtless materially assist in holding the fungus in check. They alone can not be relied upon to prevent losses when conditions favorable to the parasite occur. Of the various sanitary measures thus employed, that of covering the beds with a layer of dry straw after the tops die down, and burning, is especially recommended. Where this is not feasible for any reason a copper sulphate solution (not Bordeaux mixture), 1 pound to 5 or 10 gallons of water, may be applied after the tops and mulch are removed. Enough should be applied to wet the soil to the depth of half an inch.

Protection of the plants from infection by the *Alternaria* fungus offers the most satisfactory means of controlling the malady. Proper location, so as to afford good ventilation, setting the plants farther apart, etc., all conduce to the rapid evaporation of moisture, and this, to a degree, protects the plants from infection, since the spores require continuous moisture for several hours to insure germination and the penetration of the host. These means are of relatively little value during a rainy period continuing for several days. By far the most efficient way of protecting the plants and thus controlling the disease is the practice of spraying, success in which depends upon strict adherence to the following rules:

- (1) The spray mixture to be used must have proved its fungicidal efficiency against the spores of the fungus. Bordeaux mixture of the 3-3-50 formula has been proved both by careful laboratory tests and on the plants to be entirely effective against the parasite. The addition of Paris green or arsenate of lead is not necessary.

- (2) The fungicide must not cause the burning of the plants when thoroughly applied at the effective dilution. A 10-10-50 mixture may be safely applied, but it is entirely unnecessary, since the 3-3-50 formula has been shown to prevent the germination of the *Alternaria* spores.



FIG. 1.—GINSENG PLANT ATTACKED BY ALTERNARIA AT THE TOP OF THE LEAFSTALK.



FIG. 2.—GINSENG PLANT, SHOWING A SYMPTOM OF THE PHYTOPHTHORA MILDEW KNOWN AS "BENDING-AT-THE-LOIN." [The arrow indicates the point affected.]

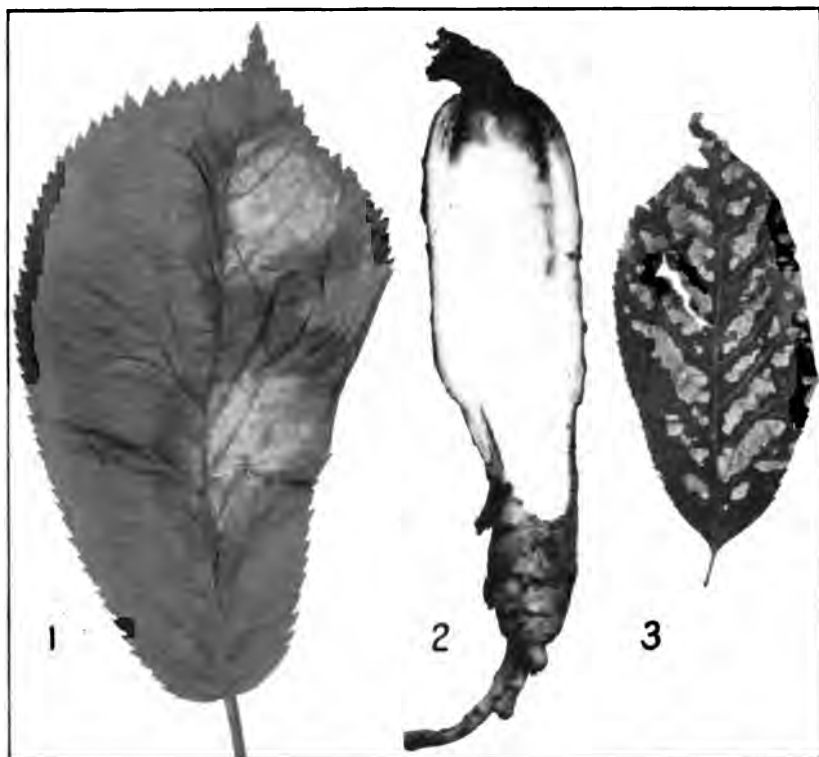
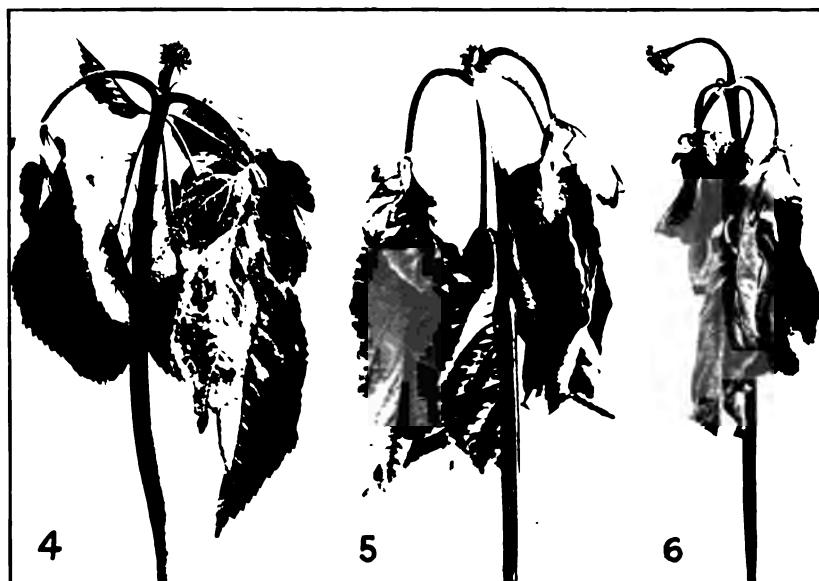


FIG. 1.—LEAF-SPOT OF PHYTOPHTHORA MILDEW ON A GINSENG LEAF. (COMPARE WITH ALTERNARIA LEAF-SPOT, PL I, FIG. 2.) FIG. 2.—ROOT-ROT LESION CAUSED BY PHYTOPHTHORA MILDEW. FIG. 3.—PAPERY LEAF-SPOT.



FIGS. 4, 5, AND 6.—GINSENG PLANTS, SHOWING ACROSTALAGMUS WILT.

(3) The fungicide must be thoroughly applied. All parts of the plants susceptible to infection—stems, leaves, and seed heads—must be covered and kept so. The development of the berries after blossoming exposes new surfaces not covered by earlier applications, and special spraying of the seed heads to prevent blasting and shelling of the berries is desirable. Since the first infections occur on the stems, it is desirable to spray very frequently when the plants are coming up and expanding. The fact that the plants in a given bed do not all come up at the same time makes frequent sprayings at this time highly desirable.

(4) Spraying should be done just before rainy periods, not after. The spores of the *Alternaria* fungus germinate only in water. The fungicide must be present on the plants when the condition favorable to the germination of the spores arrives. Once the fungus has established itself within the tissues of the ginseng neither the Bordeaux mixture nor any other fungicide can reach and destroy it. The time required for the diseased spots to appear after infection is from four days to a week. If the fungicide be applied directly after a rain in order that it may not wash off, infection will already have taken place and the spots will appear some days later in the leaves now coated with the poison. Spraying has often been condemned on account of such untimely application. For further data on spraying, the preparation of Bordeaux mixture, etc., see pages 37 to 40.

PHYTOPHTHORA MILDEW.

History.—Phytophthora mildew is a destructive disease of ginseng in Japan, where it was first reported by Hanai¹ in 1900, though Hori,² who first studied the disease and the fungus which causes it in 1904, states that it has long been known to Japanese ginseng growers. A year later, in the spring of 1905, Van Hook³ received specimens of the disease from growers in Ohio and New York. Nearly every season since, the disease has been observed in gardens here and there in New York, Ohio, Pennsylvania, etc. In 1909 it was very destructive in some beds in a garden in New York, at least 20 per cent of the plants being destroyed, stem and root. As yet the disease has not become generally destructive in this country, but its general occurrence in ginseng gardens in many States indicates that at any time, under conditions especially favorable to it, it may develop as destructively here as in Japan. Hori⁴ reports a loss of

¹ Hanai, I. On the Culture and Curing of the Idzumo Ginseng. Report, Central Agricultural Experiment Station, vol. 8, 1900, pp. 28-29. (In Japanese.)

² Hori, S. A Disease of the Japanese Ginseng Caused by *Phytophthora Cactorum* (Con. et Leb.) Schröt. Bulletin, Imperial Central Agricultural Experiment Station, Japan, vol. 1, 1907, pp. 153-162. (In English.)

³ Van Hook, J. M. A Disease of Ginseng Due to *Phytophthora*. Special Crops, n. s., vol. 5, 1906, p. 94.

⁴ Hori, S. Op. cit., p. 153.

\$25,000 from this disease in one province of Japan in the spring of 1904. It appears to have been quite destructive in many gardens in Michigan in 1911. Our observations indicate that the disease is on the increase in the ginseng gardens of this country. The same disease affects forest-tree seedlings, having long been known as a serious pest in the seedling nurseries in Germany and in this country. It is very probable that the fungus causing this disease has been brought into the ginseng gardens on wild roots or in leaf mold from the woods.

Symptoms.—The symptoms of mildew, while in a way quite characteristic, are apt to be easily confused by the grower with those of the Alternaria blight. The most common sign of the malady is the drooping of the leaflets of one of the leaves from the end of the petiole. (Pl. III, fig. 2.) It is because of this symptom that the disease is known among Japanese growers as “Koshi-ore” (bending at the loins) or “Koshi-nae” (paralysis of the loins). An almost equally striking effect of the disease is the killing of the bases of the leafstalks where they join the stem, causing the leaves to droop and hang dead about the stem. Both these types of lesion may be produced by the Alternaria blight fungus, in which case, however, the diseased parts are covered by a brown felt of spores. (See page 11.) The mildew lesions may at first show an almost indiscernible silvery white coating of the spores of the causal fungus, but this soon disappears and the surface of the diseased parts becomes soft and slimy, especially if wet weather continues. The affected portions of the stem and leafstalks have a water-soaked appearance, strikingly different from the dry, brown canker effect of the Alternaria blight. The mildew also produces large spots on the leaves (Pl. IV, fig. 1), similar in form and size to those of the Alternaria blight, but strikingly different in color. At first these spots appear dark green and water soaked, quite like those of the blight in the early stages, but soon the center of the spot becomes white, the margins remaining a dark water-soaked green. There is no rusty brown discoloration of the margins of the spots as in the blight. (Compare Pl. I, fig. 2, and Pl. IV, fig. 1.) If cloudy, rainy weather continues, the disease extends rapidly down the stem and involves the root, causing it to rot. (Pl. IV, fig. 2.) Observations in the gardens show that the roots of plants, the tops of which are killed by the mildew, invariably rot unless promptly removed and dried. The Phytophthora mildew is thus seen to be one of the few diseases of ginseng which directly affect both tops and roots. The white-rot, described later, is another.

Cause.—The mildew is caused by *Phytophthora cactorum* (Con. and Leb.) Schröt., a fungus very similar to but not the same as the one causing the late-blight of potatoes. Conidia, or short-lived spores, are produced in great abundance in the spring on the affected stems

of the first plants to be attacked and are carried to healthy plants by the wind, splashing raindrops, and possibly also by insects. Thus, the fungus spreads through the beds from plant to plant.

The chief points of attack are where the leaflets are attached to the leafstalk and where the leafstalks are attached to the main stem. In these crotches water is retained for a longer time than elsewhere on the plant, thus affording better conditions for the germination of the conidia of the fungus. As the stem dies there is formed within it great numbers of microscopic resting spores, or oospores, which pass the winter in a dormant condition, germinating in the spring and forming conidia which are carried to some of the ginseng plants as they come up, thus starting the disease anew. The injury to the plant is affected by the rootlike mycelium of the fungus, which spreads through the tissues of stem, leaf, and root, secreting a poison that kills the plant tissues, thus providing nourishment for the growth and development of the parasite.

Control.—It has been shown by experiments both in Japan and in this country that the mildew is readily controlled by spraying the plants with Bordeaux mixture. To be effective the fungicide must be applied very early, while the plants are coming up. The disease seems to be checked by the warm, dry weather of summer. It is distinctly an early-spring disease. Care must be exercised in early spraying, as there is danger of injury from spray mixtures applied just before frosts. (See page 39.) Bordeaux mixture of the strength used for *Alternaria* blight, about 3–3–50, will control this disease. Much may be done toward eradicating the mildew from the gardens by the prompt removal of diseased plants from the beds, for, as already pointed out, it is in these diseased stems that the oospores of the fungus pass the winter. The roots should be dug and dried before the fungus has time to work down the stem and rot them.

VERMICULARIA STEM ANTHRACNOSE.

History.—Reed¹ reports *Vermicularia* stem anthracnose as the first disease to make its appearance in the spring in the ginseng gardens of Missouri, usually appearing about 30 days after the plants are up. What appears to be the same disease has been found on plants received from Tennessee and Virginia. It is not regarded as directly very destructive. Many plants are attacked but few killed, the greatest loss being in the destruction of the seed crop. The lesions are said also to afford entrance for a wilt fungus.

Symptoms.—The symptoms of this anthracnose, according to Reed, are the appearance of numerous black scars on the stems of the plants. These spots gradually spread, sometimes encircling the stems. The

¹ Reed, H. S. Three Fungous Diseases of the Cultivated Ginseng. Bulletin 69, Missouri Agricultural College Experiment Station, 1905, pp. 46–48 and 56–57.

first indication of the malady is the turning brown of one leaflet after another, the disease spreading from these down the petiole to the main stalk. In some cases the lesion encircles the stem, causing it to break over. The lesions are covered with the minute black pimple-like fruit bodies of the fungus.

Cause.—The fungus *Vermicularia dematium* (Pers.) Fr. is regarded by Reed as the cause of this disease. Our own observations in New York and other Northern States indicate that it is only a saprophyte, usually appearing on stems late in the season after they have been injured or killed from some other cause. The fungus is very common on stems killed by the Alternaria blight. Specimens of plants affected with this disease from Missouri and examined by us have always shown the presence of the Alternaria-blight fungus. This, together with the fact that Reed reports no inoculation experiments with the Vermicularia, indicates that he may have overlooked the true cause of the malady which he had under observation.

Control.—The disease was found to be readily controlled by spraying with Bordeaux mixture early, about three weeks after the plants came up, repeating this every three weeks until August 1. The removal and destruction of diseased stalks in the autumn are also to be recommended. In short, the methods of control already prescribed for the Alternaria blight will be found effective against this disease.

PESTALLOZZIA LEAF ANTHRACNOSE.

History.—Pestalozzia leaf anthracnose has been reported only from Missouri by Reed¹ in 1905. It is said to be very destructive to young plants in that State. So far it has never been recognized in other ginseng-growing sections.

Symptoms.—This anthracnose attacks the base of the leaves and flower stalks, covering them with a black velvety growth and causing them to die and fall. These symptoms are very similar to those of the Alternaria blight when it attacks these parts of the plant.

Cause.—Reed found the fungus *Pestalozzia funerea* Desm. associated with these lesions and concluded that the fungus is parasitic and the cause of the disease.

Control.—Spraying with Bordeaux mixture is said to control the malady.

PAPERY LEAF-SPOT.

History.—Papery leaf-spot is observed more or less commonly every year, especially in dry seasons. During the past three years, which have been exceptionally dry in many sections, growers have sent in many specimens of plants affected with the papery leaf-spot.

¹ Reed, H. S. Three Fungous Diseases of the Cultivated Ginseng. Bulletin 69, Missouri Agricultural College Experiment Station, 1905, pp. 48, 58-59.

The disease has seldom been very destructive, usually only a few plants in certain places in the garden showing the trouble.

Symptoms.—The spots characteristic of this disease appear either between the veins or along the margins of the leaflet. At first small and circular, they rapidly enlarge and, coalescing with other spots, form large oblong or irregular-shaped areas (Pl. IV, fig. 3) of a papery texture, white or transparent, often with a yellowish tint. The last portion of the leaf to turn papery is that along the large veins and midrib which, retaining the green color for a long time, stands out in sharp contrast to the papery white areas. Growers often mistake the papery leaf-spot for the *Alternaria* blight, but the diseases are quite readily distinguished, as the spots of the former lack the rusty brown border of the latter.

Cause.—Bordeaux mixture is frequently held by growers to be responsible for this injury to the leaves, but the disease is equally common in unsprayed gardens. Our observations indicate that this spotting of the leaves results from an insufficient supply of water to the leaf tissues. The margins of the leaves and the areas between the main veins, being farthest from the water supply, are the first to suffer. As the tissues in these regions are gradually deprived of water the leaf green disappears and the tissues die and dry out, forming the spots characteristic of the disease. Of the various external factors which may bring about this lack of water supply, the following appear to be the most important: (1) Lack of rainfall (drought), the soil becoming so dry that the roots are unable to obtain sufficient moisture to supply the leaf surface exposed; (2) the presence in the beds of large tree roots, which exhaust the water supply to such an extent as to leave an insufficient amount for the ginseng; (3) insufficient shade, especially along the sides of the shack, permitting an abnormal drying out of the soil where thus exposed; (4) lack of fine feeding rootlets with their water-absorbing root hairs, due to attacks of fiber-rot or other diseases which destroy the rootlets. Under such conditions the papery leaf-spot may appear on plants in soil evidently having a sufficient water supply, but the roots being unable to absorb it the plant suffers exactly as though it was not present.

Control.—The measures to be suggested for the control of this disease are such as will correct the conditions which have given rise to the injury. These must first be determined in each case. Tile drainage will tend to equalize the moisture supply and protect the plants in dry seasons. Ginseng should not be planted in the region of large tree roots, i. e., in the feeding area of such roots. Provision should be made for the irrigation of the beds in excessively dry seasons. Injury to the absorbing rootlets should be prevented by proper treatment of the soil and roots where fiber-rot occurs. (See p. 31.)

INJURY CAUSED BY COLD FOLLOWING THE USE OF BORDEAUX MIXTURE.

History.—This injury was first observed by Whetzel¹ in New York during May and June, 1907. It was also reported during that spring from other States. Nine gardens were personally visited and the disease found to be quite destructive. One garden showed 20 per cent of the plants badly injured or killed; another 30 per cent. Reports from growers indicated losses ranging from a few plants in exposed places up to 50 per cent in some cases. Similar injury has been occasionally reported since that season, but it has never been serious.

Symptoms.—In all cases the injured plants appeared to have been affected shortly after they came through the soil. Fully expanded plants suffered but little. The injured portions of the plants appeared as though they had been dipped in scalding water. Some plants were killed back entirely to the ground. These had on a wet morning a dark-green water-soaked appearance and soon became soft, slimy, and rotten. When dry, the leaves became papery and brittle, crumbling readily between the fingers. In many cases the leaves alone suffered, the margins being burned and blackened. As the uninjured leaf tissue along the midribs grew and expanded, the leaves unfolded imperfectly, being tucked and wrinkled, with dead margins.

Where the stems were not killed outright a swelling with a russetting or checking of the epidermis appeared in a week or so. This injury is quite different from the curling or wrinkling of the leaves observed more or less commonly every spring and attributed to frost.

Cause.—From the fact that the disease has appeared only in gardens that were sprayed with Bordeaux mixture and only (to any extent) during abnormally cold weather, the conclusion seems inevitable that it is due to a combination of these two factors. The records show that the most serious injury occurred in those gardens where the Bordeaux mixture was applied during a day just prior to a heavy frost.

Control.—Little can be suggested by way of control, except that care be taken not to spray during extremely cold weather. Applications should be made during the forenoon in early spring on sunny days. Weather conditions especially favorable to this injury are likely to be rare. It is apparently the wetting of the plants just before a frost, rather than the fact that Bordeaux mixture was applied, that brings about the injury.

THE DAMPING-OFF OF SEEDLINGS.

History.—Ever since growers began to raise ginseng from the seed they have been more or less troubled with the loss of many of the

¹ Whetzel, H. H. Bordeaux Cold Injury of Ginseng during the Spring of 1907. *Special Crops*, n. s., vol. 6, 1907, pp. 184-187.



FIG. 1.—BED OF GINSENG PLANTS, SHOWING SEEDLINGS DESTROYED BY DAMPING-OFF WHERE THE DRIP FROM THE SHADING FALLS ON THE BEDS.

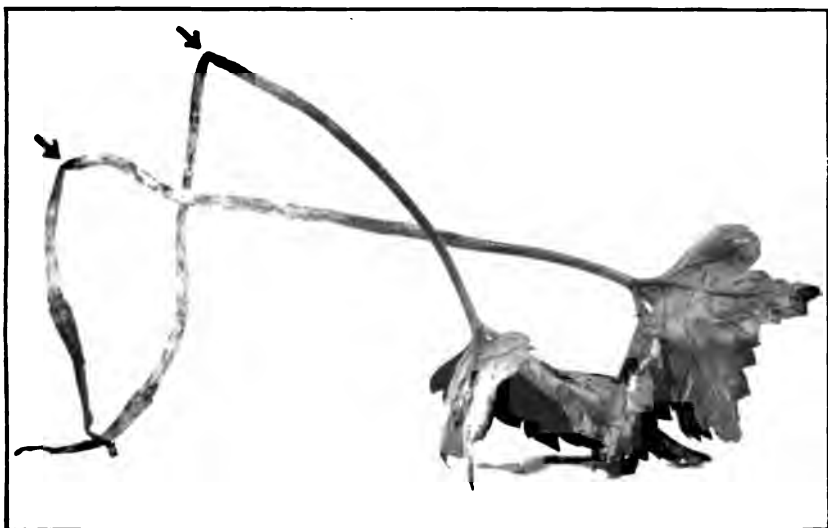


FIG. 2.—SEEDLINGS AFFECTED WITH DAMPING-OFF.

[Note the sharp angle at which they bend over. (Photographed by Van Hook.)]

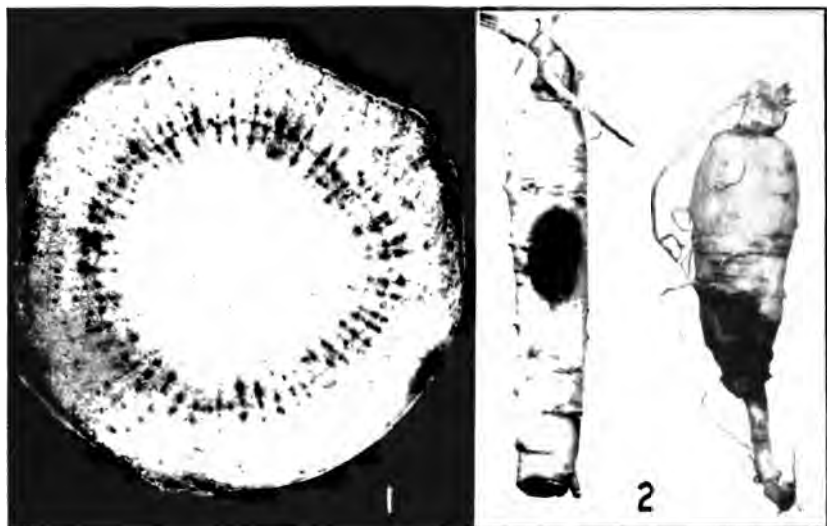


FIG. 1.—SECTION OF GINSENG ROOT, SHOWING A DISCOLORED RING OF SAP TUBES DUE TO ACROSTALAGMUS WILT. FIG. 2.—RUST SCAB ON OLD ROOTS.



FIG. 3.—ROOTS OF GINSENG, SHOWING THE FIBERS OF OLDER PLANTS ROTTED BY RUST.

seedlings, especially in wet seasons. The earlier editions of *Special Crops*, a publication devoted to ginseng culture, are full of inquiries from growers which indicate that the trouble was caused by this damping-off of seedlings. This disease takes a heavy toll from the seedling beds. The little plants succumb quickly and often large areas in a bed are depopulated. Where the drip from the shading falls on the beds, thus affording moisture conditions especially favorable to the parasite causing the trouble, the losses are usually heavy. (Pl. V, fig. 1.) Half of the seedlings are frequently lost in a wet season.

Symptoms.—The wilting or drooping of seedlings may be due to several causes, and on careful examination the symptoms in each case are found to be different. In the case of damping-off, the tender stem just at the surface of the soil becomes soft and rotten and the top drops over, forming a sharp angle at the point of injury. (Pl. V, fig. 2.) If the stem droops in a smooth curve the trouble is usually to be looked for in the root, as in end-rot, described on page 28. Damping-off usually occurs in places where for some reason the soil is excessively wet, and as the causal fungus spreads from plant to plant through the soil several plants side by side are usually affected. No bronzing, yellowing, or reddening of the leaves accompanies the wilting from damping-off, as is the case in end-rot.

Cause.—The cause of damping-off of ginseng seedlings is, according to Van Hook,¹ the fungus *Rhizoctonia*. No extensive investigation of damping-off as it occurs in ginseng has been made. However, other fungi besides *Rhizoctonia* have been observed in damped-off seedlings, viz, the mildew fungus (*Phytophthora cactorum*) and the common damping-off fungus (*Phythium debaryanum*). Whatever is the causal organism, its destructiveness is conditioned directly upon the presence of excess moisture in the surface soil.

Control.—Various methods of preventing damping-off have been advocated by growers and others. Spraying the beds with various chemicals, especially dilute ammonia, has been held to be very effective. From the nature of the disease and the conditions which are known to favor it, two things are to be suggested: (1) The necessity of preventing excessive moisture in the seed beds, either by thorough drainage or by the exclusion of part or all of the rain, and (2) the planting of the seedlings in rows or drills, so that the soil between the rows may be loosened after each shower by hoe or other tool and thus, by drying out the soil, excessive moisture may be kept from the tender base of the stem of the seedling.

¹ Van Hook, J. M. Diseases of Ginseng. Bulletin 219, New York (Cornell) Agricultural Experiment Station, 1904, pp. 174-175.

WILTS.

ACROSTALAGMUS WILT.

History.—*Acrostalagmus* wilt was one of the first diseases of ginseng to be carefully studied, having been quite fully described by Van Hook¹ in 1904. It appears to have been at that time the disease most commonly met with in ginseng gardens. Observations and records show that since that time it has been quite generally present each season in the gardens of New York, Pennsylvania, Michigan, Ohio, New Jersey, Wisconsin, Kentucky, Tennessee, etc. It has not been reported from Missouri or other States on the western border of the ginseng-growing region. A wilt was reported from Missouri by Reed in 1905, but from his description it is to be regarded as different from the disease here under consideration. While the wilt is very widely distributed and appears in most gardens to some extent every spring, it has never become epidemic and completely destructive like the blight. Whether under especially favorable conditions it might become a formidable malady remains to be seen. It appears to be one of those diseases which, like the white-rot, take a small annual toll that in the aggregate, however, amounts to considerable. The loss from this disease seldom exceeds 5 to 10 per cent, though beds have been examined in which at least 20 per cent of the plants were killed.

Symptoms.—This wilt makes its appearance rather early in the season, usually about the time the leaves become expanded. New infections do not appear to occur during the latter part of the growing season. The first evidence of the malady is the gradual wilting of the plants here and there in the beds, at first a mere drooping of the leaves, as on a hot day. The entire top soon wilts and dies. (Pl. IV, figs. 4, 5, 6.) If the plant is dug up, the roots usually will be found to appear perfectly healthy, with no external evidence of rot or other lesion. If the root be cut across, however, a part or all of the ring of sap tubes will be found to be yellow. (Pl. VI, fig. 1.) This yellowing of the sap tubes is a certain symptom of the wilt. If the roots are left in the ground, they eventually rot.

Cause.—The cause of this disease is a fungus (*Acrostalagmus* sp. ?), which enters the root probably through the old stem scars of previous seasons. Here in these scars the ends of the sap tubes which connected the roots with the stem are exposed and offer an open pathway for the entrance of the fungus into the root. Under the microscope the sap tubes of the neck and the root are seen to be filled with the matted threads of the fungus mycelium (fig. 3). These prevent the proper passage of water to the stem and the leaves above, and they

¹ Van Hook, J. M. Diseases of Ginseng. Bulletin 219, New York (Cornell) Agricultural Experiment Station, 1904, pp. 168-174.

wilt. While the plant is still alive the fungus seems to be confined to the sap tubes, but as soon as the top wilts and dies the parasite probably spreads throughout the root, rotting it or at least admitting other rot organisms that complete the disintegration. The spores of the fungus are very minute and are formed on slender branched stalks which may develop over the surface of the rotted root or on the dead stems. (Fig. 4, *a*.) They probably find their way to the healthy plants through the movements of the soil water or the wind. The mycelium of the parasite forms minute black sclerotial masses (fig. 4, *b*), which appear to be a sort of resting condition and may serve to tide the fungus over from one season to the next in the soil.

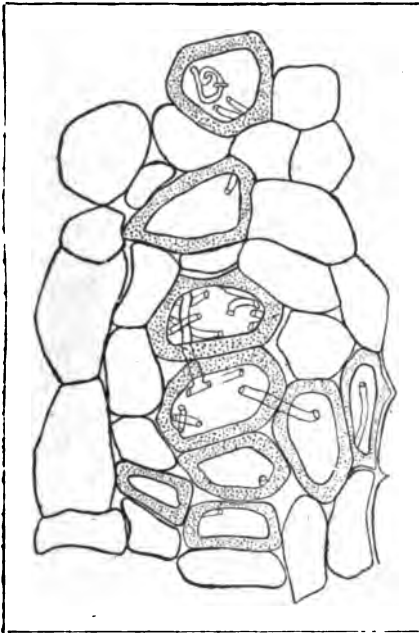


FIG. 3.—Section across sap tubes of root filled with mycelium of the *Acrostalagmus* wilt fungus. (After Van Hook).

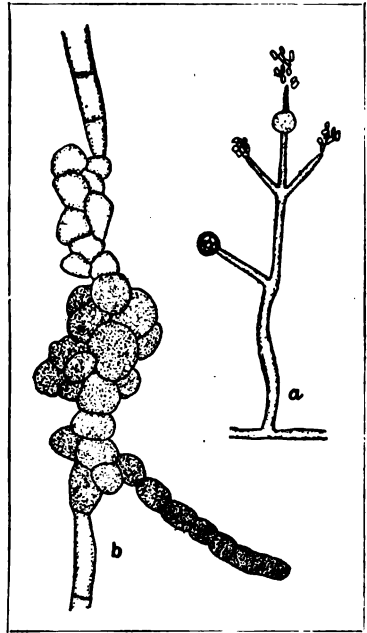


FIG. 4.—*Acrostalagmus* wilt: *a*, Spore-bearing stalk of the wilt fungus; *b*, sclerotial bodies formed in the mycelium.

Control.—Until more is known of the life habits of this wilt fungus little can be suggested as to its control. It is evident from what is already known that no method of spraying is likely to be effective. The prompt removal of affected plants, root and all, as soon as detected will do much to eradicate the parasite by preventing the formation of spores or the distribution through the soil of the resting sclerotia. Soil sterilization may prove effective. Wilting roots, if dug at once and dried, are but little injured. From extensive observations it appears possible that mulching with sawdust may favor the development of this malady.

FUSARIUM WILT.

History.—Fusarium wilt, while similar in some of its symptoms to the Acrostalagmus wilt, is evidently distinct from it. It was first reported by Reed ¹ from Missouri in 1905, and, so far as we know, has never been found in ginseng in any other State since. According to Reed, this wilt is often very destructive, destroying whole plantations in a week. He regarded it as the most dangerous disease occurring in the ginseng gardens in Missouri.

Symptoms.—The Fusarium wilt appears somewhat later in the season (about July 1) than the Acrostalagmus wilt of the northeastern States. There is a gradual wilting of the leaves, but it is accompanied by a yellowing and dropping, which symptoms are wanting in the case of the wilt caused by Acrostalagmus. Both stem and root are invaded and the sap tubes are yellowed.

Cause.—This wilt is caused, according to Reed, by one of the wilt fungi, a Fusarium. It is thought to enter the stem first rather than the root and is believed to find its way in through lesions of the stem anthracnose, another disease, which attacks the stem earlier in the season near the base (p. 19). It produces its spores within the sap tubes. The fungus probably passes the winter in the old dead stems or on decaying vegetable matter in the soil, infecting healthy plants the next season.

Control.—Reed holds that no method of soil sterilization is likely to prove effective against the disease. The experience of certain growers in Missouri indicates that thorough spraying to prevent the stem anthracnose and other diseases through the lesions of which this parasite is supposed to enter will control the Fusarium wilt. The prompt removal and destruction of all diseased plants are to be recommended as profitable sanitary measures. Reed suggests the development of wilt-resistant varieties of ginseng, pointing out that there are always some plants in badly infested gardens that come through the epidemic uninjured. Seed from these should be saved and propagated separately.

GALLS.

NEMATODE ROOT-GALL.

History.—Ginseng is one of about 480 different plants ² subject to nematode root-gall. Just when it was first observed on ginseng is not known, but early in the cultivation of this crop it was found by the growers when transplanting the roots, and Mr. George Stanton, the

¹ Reed, H. S. Three Fungous Diseases of the Cultivated Ginseng. Bulletin 69, Missouri Agricultural College Experiment Station, 1905, pp. 48-55, 59-65.

² Bessey, Ernst A. Root-Knot and Its Control. Bulletin 217, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1911, pp. 18, 72.

NOTE.—Growers who are especially interested in the nematode root-gall are urged to write to the Superintendent of Documents, Washington, D. C., for a copy of Dr. Bessey's bulletin on this subject; price 15 cents.

pioneer grower in New York, was accustomed to attribute all the ginseng ills of the early days to "nimetodes," as he called them. Van Hook¹ in 1904 was the first to give a careful description of these galls on ginseng. The evidence indicates that it is a widely distributed pest of this crop. Seriously infested gardens have been examined or reported from New York, Michigan, Ohio, and Wisconsin, as well as from the States in the southern portion of the ginseng-growing region. Van Hook inclines to the opinion that it is a natural pest of the wild ginseng and was thus introduced into the gardens. Bessey regards the parasite causing these galls as a native of the Tropics of the Old World which has gradually spread into the temperate regions, north and south. The injury to the crop is generally considered serious, as it greatly reduces the market value of the dry root and may destroy seedlings, but it is well known that older affected roots will continue to send up strong, healthy stalks, producing good crops of seed year after year.

Symptoms.—As pointed out, the tops seldom give evidence of the disease. It is only when the roots are dug up and exposed that the grower becomes aware of the injury from the nematodes. The roots, especially the fibers and smaller rootlets, are seen to be full of nodules or swellings of various sizes. (Pl. VII.) The galls are at first more or less smooth and white, becoming brownish and roughened with translucent watery spots as they become old, finally decaying. When affected rootlets die new roots are sent out, but are soon attacked by the parasite.

Cause.—These galls result from the attacks of the minute nematode worm (*Heterodera radicola* (Greef) Müll.). It has been shown that this worm is a very common cause of root galls of many wild and cultivated plants, being most common and destructive in warm climates. The larvæ, which may live in moist soil for a time, bore into the roots and by their presence stimulate abnormal growth of the root tissues, resulting in the formation of the galls. These worms are very small and invisible to the naked eye, so that it would require from twelve to fifteen thousand of them end to end to span an inch. There are males and females, but the former die shortly after fertilizing the females, which then swell to a globose form, becoming filled with eggs. The eggs are laid within the tissues of the root or in the soil, where they soon hatch and develop the larval stage again. Those in the root shortly find their way into the soil by the disintegration of the gall or by boring directly out. After moving about in the soil for a time they penetrate into healthy roots and again set up the disease. The complete life cycle may take place within four weeks, or longer, depending upon the temperature of the

¹ Van Hook, J. M. Diseases of Ginseng. Bulletin 219, New York (Cornell) Agricultural Experiment Station, 1904, pp. 176-181.

soil. In the cold soils of the North fewer generations of the worms develop than in the warmer soils and longer seasons of the South. The worms pass the winter either as larvæ in the soil or in the galls themselves as nearly mature females filled with eggs.

Control.—The frequent statement that thorough freezing of the soil of the ginseng bed will rid it of the nematodes is now known to be untrue. The following suggestions as to possibly effective means of control are the best that can be made at present. The roots should be dug in the fall, the galls cut away as much as possible, the roots dipped for 10 minutes into a solution of formaldehyde, using 1 part of the formalin solution to 100 parts of water. This is to kill the eggs and larvæ that may adhere to the roots. Replant in a soil in which ginseng has not been grown or treat the soil of the old beds with formalin, as explained on pages 40–41, before resetting the roots. To prevent the infection of the healthy roots, care should be exercised to prevent the transfer of infested soil from bed to bed. Tools used in infested beds should be disinfected by dipping in the formaldehyde solution before using in clean soil. These worms are easily killed by drying the soil, so that repeated stirring and drying of the soil during the summer might greatly reduce the number of worms in badly infested beds. The selection of gall-free roots, occasionally found in badly infested beds, is to be recommended for propagation, in the hope of obtaining a strain of ginseng resistant to the attacks of the worms.

ROTS.

RUST (FIBER-ROT, END-ROT).

History.—Rust (fiber-rot, end-rot) was first observed in the ginseng gardens of New York by Van Hook¹ in 1904. He describes it only on seedlings, giving it the name of “end-rot” because of the characteristic rotting away of the taproot. (Pl. VIII, fig. 1.) During 1908 and 1909² the disease was very destructive to seedlings throughout the ginseng gardens of the East. During these same years and even earlier, growers had complained of a disease of the older roots to which they gave the name of “rust.” This disease was investigated at the Cornell station during the seasons of 1909³ and 1910⁴ and the conclusion reached was that it is but another form of the end-rot of seedlings. From an examination of many gardens in the principal ginseng-growing States during the seasons

¹ Van Hook, J. M. Diseases of Ginseng. Bulletin 219, New York (Cornell) Agricultural Experiment Station, 1904, p. 176.

² Whetzel, H. H., and Rankin, W. H. End Rot or Fiber Rot of Seedlings. Special Crops, n. s., vol. 3, 1909, pp. 143–145.

³ Whetzel, H. H., and Rankin, W. H. Fiber Rot or Rust of Ginseng Roots. Special Crops, n. s., vol. 8, 1909, pp. 146–147.

⁴ Whetzel, H. H., and Osner, George. The Fiber Rot of Ginseng and its Control. Special Crops, n. s., vol. 9, 1910, pp. 411–416.



GINSENG ROOTS, SHOWING NEMATODE GALLS.



FIG. 1.—ROOTS OF SEEDLING PLANTS OF GINSENG, SHOWING THE EFFECT OF END-ROT.



FIG. 2.—BED OF GINSENG PLANTS, SHOWING THE EFFECT OF RUST ON LIMED AND UN-LIMED SOILS.

[The limed soil is in the foreground, the unlimed at the back. The roots were of the same age and were set at the same time.]

of 1910 and 1911 and from specimens received from many others it is evident that this disease is, if anything, more widespread and destructive than the *Alternaria* blight. The average annual loss to the ginseng interests of the country from this disease must be not far from 25 per cent, and in many cases considerably in excess of this. Whole beds of seedlings are frequently rendered worthless and the growth of older plants so checked as to make their further cultivation unprofitable. A disease very similar to this, if not identical with it, is very destructive in the ginseng gardens of Chosen (Korea). It is known there as the red-rot.

Symptoms.—The symptoms of this disease vary considerably, depending upon the age of the root, the part attacked, the character of the weather, the severity of the infection, etc. In the case of seedlings the most striking symptoms during a dry season are a gradual change from the dark green of healthy leaves to a light-green shade, followed by premature coloring in shades of red and yellow, the leaflets finally withering and the stem wilting. Frequently the leaflets, instead of changing to a light green, take on a peculiar purple-bronze color. In wet weather the color changes are usually not so striking and the wilting is more sudden, the stem bending in a curve until the leaves (still green) touch the ground, differing strikingly from seedlings affected with damping-off, in which disease the stem bends at a sharp angle near the ground. (See Pl. V, fig. 2.) An examination of the roots of these seedlings will discover the fibers nearly or quite rotted away, with frequently only a bulblike crown bearing the prematurely and weakly developed bud. (Pl. VIII, fig. 1.) The rotted fibers are of a rusty brown or black color. In older plants the tops show similar symptoms in the way of premature coloration and wilting. The fibers of the root are more or less rotted (Pl. VI, fig. 3) and in severe cases entirely gone, leaving the root in a bare and stubby condition (Pl. VI, fig. 2) entirely without the absorbing apparatus necessary to supply the top with water. Both seedlings and older roots usually show brown scabby areas of dead skin, which may slough off, leaving the root more or less "pocked" or disfigured. Sometimes these rusty areas involve the entire surface of the root; sometimes the rusty scab is very superficial; in other cases it extends quite deeply into the flesh of the root. The diseased tissue is usually dry and spongy. However, the rust lesions seem to afford entrance to soft-rot organisms, which by penetrating deeply doubtless greatly increase the injury. This appears to be the case especially in wet seasons. We are inclined to the belief that the soft-rot (p. 32), so destructive in wet soils, is often, if not commonly, a secondary malady following the rust. While the absolute proof of the common cause of these different symptoms on seedlings and older roots has not yet been established, the evidence thus far

accumulated indicates that they are one and the same thing and may be, at least for the present, referred to as the "rust."

Cause.—While it can not be stated definitely that the fungus *Thielavia basicola* (B. and Br.) Zopf. is the cause of this disease (inoculation experiments not yet having been made), nevertheless the evidence points in that direction. Van Hook in 1904 reported the cause of the disease as unknown, but later in the same year at the Ohio experiment station he discovered¹ the fungus *Thielavia* on the roots of some ginseng seedlings affected with the end-rot. This fungus is a common parasite, causing a root-rot of numerous cultivated plants in this and other countries, tobacco,² violets, begonias, peas, and other legumes being among those most commonly attacked.³ The fungus appears to be quite commonly associated with the lesions on the ginseng roots. This, together with its well-known parasitism on the roots of other plants, seems to warrant the assumption that it is the cause of the rust. This fungus is known to live in soils rich in humus, especially cultivated soils. It becomes parasitic under favorable conditions. It is now known that it is especially favored in its parasitism by an alkaline condition of the soil. In the natural forest habitat of the ginseng the soil is acid and the fungus does not appear to attack it.

During the past five or six years there has been a very general use of wood ashes and lime on the ginseng beds. This appears to account very largely for the increasing prevalence and destructiveness of rust. (Pl. VIII, fig. 2.) These substances make the soil alkaline. Another practice of growers which has doubtless gone far to increase the ravages from this parasite is the growing of seedlings on the same soil year after year or on beds from which a crop of mature roots has been dug. Under such a practice the soil becomes literally infested with the spores of the parasite. The fungus produces three kinds of spores, all of which have their share in the spread and perpetuation of the parasite. The long short-lived conidia are produced in great abundance on the diseased roots, especially in moist soil, and are probably carried by the currents of water in the soil or by earthworms, etc., to the healthy roots, there to bring about new infection. The dark-brown thick-walled resting spores are produced in great abundance on the lesions, especially in dry soils. These do not germinate until after a considerable period of rest. A third kind of spores, produced eight in a sac, are known as ascospores. These and the large brown resting spores evidently serve to winter the fungus in

¹ Selby, A. D. Tobacco Diseases and Tobacco Breeding. Bulletin 156, Ohio Agricultural Experiment Station, 1904, p. 96.

² Gilbert, W. W. The Root-Rot of Tobacco Caused by *Thielavia Basicola*. Bulletin 153, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1909, pp. 1-55.

³ Duggar, B. M. Root-Rot of Tobacco, Violets, Peas, Lupines, etc. Fungous Diseases of Plants, 1909, pp. 210-213.

the soil, while the conidia are chiefly responsible for the spread of the fungus during the growing season.

While the fungus appears to be common in many cultivated soils, it is probably true that it has been introduced into new plantings on the roots purchased for setting the garden. It is spread through the garden in the soil on the shoes and tools of workmen. There is no evidence to indicate that it may be introduced with the seed. The injury to the root results from the growth within its tissues of the rootlike mycelium of the fungus. This mycelium originates from the germinating spore. It spreads through the tissues of the root, killing them and absorbing from them food for its own growth.

Control.—It has been found that in the case of tobacco seedlings the loss from the disease is greatly reduced by planting each year on new soil. While this is often feasible with ginseng seedlings, it could hardly be practiced with profit to the older roots, which should stand in the same soil for several years. Besides, many growers have a limited area in which to grow the crop, and the cost of moving the shading every season even for seed beds is not always practicable.

In view of the known relation of the parasite to alkaline soils the application of acid fertilizer is to be recommended. Briggs,¹ in working on the control of this disease in tobacco, found that the application of acid phosphate (treated rock) at the rate of about 1,000 pounds per acre very largely controlled the trouble. This is now quite generally used by ginseng growers and the results, while not uniformly satisfactory, have in many cases greatly reduced the disease. The fact that most gardens where the acid phosphate has been applied have previously received heavy coats of wood ashes or lime, or both, doubtless accounts for the failures reported. A chemical examination of the soil from a certain ginseng garden in Michigan last year showed that it was so alkaline from excessive applications of wood ashes that it would require 150 tons of acid phosphate per acre to neutralize it. Evidently the only thing to do in such a case is to abandon the soil for ginseng culture. Many growers have applied more than a ton of the acid phosphate per acre with good results. There appears to be little danger in overapplications of this in most gardens at present.

It has been found in Chosen (Korea) that the older roots affected with the rust may be largely cured in one season by dipping them in Bordeaux mixture for about 10 minutes and then, while still wet, planting them out in clean soil. At least one case is known in this country where such treatment has given marked results. Some growers report the rotting of roots following their treatment.

For seedling beds and old beds in which roots are to be reset, sterilization of the soil with steam or formalin is to be recommended.

¹ Briggs, L. J. The Field Treatment of Tobacco Root-Rot. Circular 7, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1908, pp. 1-8.

(See p. 40.) Good results should not be expected if diseased or untreated roots are set in clean or sterilized soils. Even where sterilized, an application of acid phosphate is desirable.

Care should always be exercised to prevent the dissemination of the fungus in uncontaminated soils by the tools of workmen.

CORROSIVE-SUBLIMATE INJURY.

Among the substances early suggested for the treatment of ginseng roots affected with the rust was corrosive sublimate. This was doubtless due to the fact that growers, knowing its effectiveness against certain diseases of the potato tuber, notably the scab, hastily concluded that it would also be equally safe and efficient in the case of the rust on the roots of ginseng. Many growers tried the treatment during the autumn of 1910 with results quite uniformly disastrous, as shown at digging time in the autumn of 1911.

The strength of the solution commonly used appears to have been 1 ounce of the corrosive sublimate to 10 gallons of water, soaking the roots in this 10 minutes. A number of gardens were examined in which some of the roots in certain beds had received the above treatment, while other roots in the same bed had not been so treated. The treated roots uniformly showed serious injury. The skin of these roots had turned a reddish brown in color, not greatly unlike the rust but more uniformly covered with the discoloration. The fibers had all been destroyed and the beds set were not of normal size when compared with those of untreated roots growing in the next row in the same bed. Untreated roots were comparatively free from rusty discoloration, and the fibers were quite normal in length and numbers. It was evident that the corrosive-sublimate treatment alone was responsible for the injury.

SOFT-ROT.

History.—The soft-rot was one of the first diseases to attract the solicitous attention of the pioneer ginseng growers. The completeness of its destruction and the rapidity of its progress, especially in wet seasons or in wet places in the garden, soon induced the growers to bring it to the attention of pathologists. Van Hook¹ found it very destructive throughout the State of New York in 1903. It was also reported from other States. He says of it "In places the loss from this cause was enormous, and it is certainly safe to state that the greatest loss of ginseng in 1903 was from this rot." He records a case in which two-thirds of the plants in the bed were destroyed. The disease becomes most destructive during rainy periods in the summer, often in July and August. In 1909 the

¹ Van Hook, J. M. *Diseases of Ginseng*. Bulletin 219, New York (Cornell) Agricultural Experiment Station, 1904, pp. 182-183.



GINSENG PLANT, SHOWING WILTING OF THE LEAVES CAUSED BY SOFT-ROT.



FIG. 1.—ROOT OF GINSENG, SHOWING SOFT-ROT STARTING AT THE CROWN. FIG. 2.—ROOT AND BUD OF GINSENG CUT OPEN, SHOWING BLACK-ROT.



FIG. 3.—ROOT AFFECTED WITH BLACK-ROT, SHOWING SCLEROTIA AND MUMMIED BUD.



FIG. 4.—CUPLIKE FRUIT BODIES FORMED THE SECOND SEASON ON A ROOT AFFECTED WITH BLACK-ROT.

malady was very destructive in the ginseng-growing States west of New York, especially in Ohio and Indiana. That section suffered from excessive rainfall, while in the East it was very dry and little loss from the soft-rot was experienced. In 1911 the reverse conditions obtained, and again the soft-rot was the most destructive disease in New York and Pennsylvania. Past experience indicates that during wet seasons losses more or less serious are to be expected from this disease.

Symptoms.—The first indication of the soft-rot in the roots is a marked color change in the leaves of affected plants. This is usually not evident until the disease has made considerable progress in the root. The leaves appear rather thin and delicate, lack the dark rich-green color of healthy plants, and as the disease progresses in the root the leaves take on tinges of red and yellow as though maturing for autumn. In most cases the leaves remain erect until the complete rotting of the root; then the stem drops over or the leaves wilt about it. (Pl. IX.) The exact cause of this brilliant coloration of the leaves can not be explained at present. It appears to be a constant symptom of the soft-rot and is quite common in the case of other root rots, as pointed out in discussing the fiber-rot or rust.

On digging up plants the tops of which show a pale-green color, the first indication of the malady, the root will be found to show rot at some point. The rotting may begin at the crown (Pl. X, fig. 1) where the stem arises, the entire neck being involved, and spread from this downward, entirely destroying the root; or it may attack the fine fibers, gradually invading the larger rootlets and at last the main root itself (Pl. XI). If dug when the tops show the final stages of coloration, the root will be found to be a mass of soft, mushy consistency. It can scarcely be removed from the soil without breaking or crushing. The external examination of a partially diseased root shows a quite distinct line of demarkation between diseased and healthy tissue. The outer covering or skin of the root is for a long time intact, showing the watery brown appearance of the rotted flesh beneath, in sharp contrast to the white or pale yellow of the healthy portion. On cutting open a partially rotted root the tissues are found to be rather tough but watery and discolored. They soon become soft, like the rotting tissues of other vegetables attacked with soft-rots. The rotting roots give off a very strong offensive odor.

Cause.—The general characters of the diseased roots are so similar to those of the roots of other vegetables attacked with soft-rots that one is inclined to expect a similar cause here, namely bacteria. Certain bacteria have been found quite constantly associated with the rot in the ginseng roots. Preliminary inoculations made with these bacteria into healthy roots during the summer of 1911 resulted in the characteristic rotting of the roots, but only when an excessive amount

of water was applied to the soil. It has long been known that moisture is an important factor in the occurrence and severity of this disease. Van Hook was the first to point out that the soft-rot was most destructive where the soil was poorly drained, packed, and wet. That the disease is most common and destructive in wet seasons or in wet places in the garden and in heavy soils rather than in light, sandy ones, and that it is readily controlled by tile drainage, all show the marked influence of excessive moisture on the production of this rot.

Control.—The proper lines along which the control of this disease is to be worked out have already been indicated. All soft-rotted roots should be removed as soon as discovered. This will do much toward reducing the causal organisms in the soil. All healthy roots should be taken up in the autumn and before transplanting a tile drain should be placed under the middle of each bed, as described on page 44. This will not only remove the excess water promptly, but will better equalize the water supply in the soil throughout the season. Where the disease has been very destructive in certain beds it may be desirable to treat the soil with steam or formalin, as described on pages 40–42.

SCLEROTINIA WHITE-ROT.

History.—The white-rot, or crown-rot, as it has sometimes been called,¹ is known to occur in most ginseng-growing regions. Specimens have been received or collected from many ginseng gardens in New York, Ontario, Ohio, Michigan, and Wisconsin. Although a widespread malady it is rarely destructive, usually only a plant here and there in a garden showing the disease. Occasionally, under especially favorable conditions (excessive moisture), it may become sufficiently destructive to attract the grower's attention. The loss from the disease in the total must be quite large. A few roots rotted in nearly every ginseng garden each year will in the aggregate mean a loss of many dollars to the ginseng industry. The disease is a common malady of many cultivated plants, especially truck-garden and greenhouse crops. It is known under various names according to the crop affected, e. g., the lettuce drop, the stem-rot of tobacco, the Sclerotinia disease of cucumbers, etc. This doubtless accounts for its common occurrence in ginseng beds, as many such beds have been made in old gardens.

Symptoms.—The white-rot usually appears in the growing plants during rainy periods in the spring or early summer. Affected plants wilt and sometimes fall over, owing to a rotting of the stem at its base, and usually involving the crown of the root.

¹ Rankin, W. H. Root Rots of Ginseng. *Special Crops*, n. s., vol. 9, June, 1910, pp. 349–360.
Osner, G. A. Diseases of Ginseng Caused by Sclerotinia. [A paper presented before the Indiana Academy of Sciences in December, 1911.]



FIBERS AND SIDES OF THE MAIN ROOT OF A GINSENG PLANT ATTACKED BY SOFT-ROT.



FIG. 1.—ROOTS AND STEMS OF GINSENG AFFECTED WITH SCLEROTINIA WHITE-ROT.

[Note sclerotia on the side of root and within the stems.]

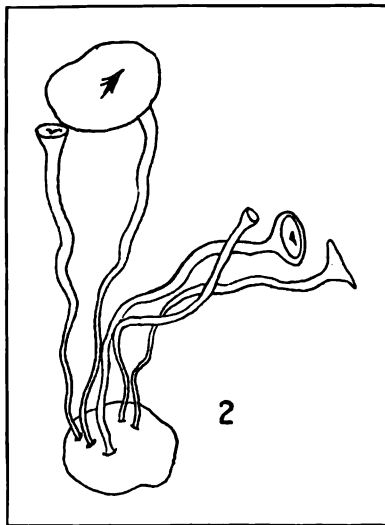


FIG. 2.—CUP-SHAPED FRUIT BODIES WHICH ARISE FROM SCLEROTIA OF THE WHITE-ROT FUNGUS.



FIG. 3.—LEAF INJURY TO A GINSENG PLANT CAUSED BY NITROGENOUS FERTILIZERS.

The diseased stem is bleached, soft, and often shows a white cottony felt over the surface. Large, black sclerotia or resting bodies of the fungus are often formed inside of the stem in the pith. (Pl. XII, fig. 1.) The disease has also been observed to attack the upper part of the stem. The point of attack in such cases is the place where the leaf stems are attached to the stalk. The petioles then rot and the leaves droop, but it is most commonly the root that is affected! In the spring the attack is usually through the base of the stem into the crown of the root, as already described. During the autumn rains roots are often infected through injured rootlets or fibers, the root rotting from the tip upward. The roots affected with this malady become soft and doughy, very watery, and tough but nonelastic. The rotted tissue remains white, hence the name, white-rot. The white mycelium of the fungus penetrates throughout the tissues of the root and grows out through the lenticles, forming bunches or tufts of cottony white felt, in which large black sclerotia rapidly develop (Pl. XII, fig. 1), like those of the stem already described. These sclerotia are diagnostic of this disease. They are hard tuberlike bodies, varying from the size of a grain of wheat to that of the end of the finger, black without, but white within. Diseased roots, if wrapped up and laid away in a place not too dry, will be covered with these bodies in a few days.

Cause.—The sclerotia-forming fungus found to be constantly associated with the white-rot appears to be *Sclerotinia libertiana* Fckl., a fungus which, as already pointed out, causes a rot of many garden plants. From the tuberlike sclerotia, as they lie buried in the soil in the spring, grow tiny cuplike fruit bodies (Pl. XII, fig. 2), in which the spores of the fungus are produced and shot in great numbers into the air. These spores, carried by the air currents in the garden, fall on the stems, and germinating in the moisture there send a root-like germ tube into the tissues. This germ tube grows rapidly, forming a much-branched and ramifying mycelium; which soon involves not only the base of the stem but also the neck and the root, causing the rot and giving rise to the sclerotia already described. These sclerotia are the wintering tubers of the fungus and the only means by which it survives from one season to the next.

Control.—From the very nature of the disease it is evident that spraying can have but little effect in its control. Since excessive moisture in the soil and in the air of the shack favors the growth and development of the parasite, it is evident that tile drainage and efficient ventilation of the shack are the first measures to be taken. As the fungus survives from year to year by means of the sclerotia alone, it is plain that to destroy them or, better, to prevent their formation, is the second step to be taken to reduce the losses from this

disease. Stevens¹ has shown that this disease in lettuce may be entirely controlled by the prompt removal and destruction of diseased plants before sclerotia have had time to form. A similar practice in ginseng beds should prove effective. A daily inspection during the growing period in the spring and early summer should be made, especially during rainy spells. All diseased plants, root and stem, should be carefully removed in a tight basket or bag and destroyed at once by burning them. The soil where the root was removed should be soaked with a solution of copper sulphate or Bordeaux mixture. Soil sterilization can not be depended upon to be effective against this disease.

SCLEROTINIA BLACK-ROT.

History.—Black-rot is doubtless a disease originally affecting wild ginseng. Growers who have seen the disease in the gardens declare that they have found black mummied roots in the woods. It was early known as a dangerous disease of cultivated ginseng. Van Hook² reports it in 1904 from a garden in New York, where it had occurred for at least six years. It is not a common disease, having been reported from only a few gardens in widely separated regions in New York, Michigan, and Wisconsin. It is usually not extensive in a garden, being confined to small areas in the beds, in which, however, all the roots are killed.³ At least one grower is known to have abandoned the cultivation of ginseng chiefly on account of the ravages of black-rot.

Symptoms.—The first evidence of this disease is shown by circular bare spots in the beds where the plants have failed to come up in the spring. Roots dug from these areas, if affected with the black-rot, are coal black in color, devoid of fibers, but with the bud intact and black like the root. The surface of the root usually shows numerous black lumps (sclerotia) the size of a sweet-pea seed or smaller. (Pl. X, fig. 3.) If the root be cut open only the outer rind is found to be black, tough, and pliable. The center is white (Pl. X, fig. 2), spongy, and watery. There is no offensive odor as in soft-rot, but the natural flavor of the root is lost and it has become somewhat bitter, like quinine. During the first season after it becomes diseased, the root, if left in the soil, remains plump and firm. By the second season it blackens through, shrinks, and finally decays.

Cause.—The cause of this disease is a fungus (*Sclerotinia panacis* Rankin)⁴ peculiar to ginseng. The outer rind of the root is first

¹ Stevens, F. L. A Serious Lettuce Disease. Bulletin 217, North Carolina Agricultural Experiment Station, pp. 16-21.

² Van Hook, J. M. Diseases of Ginseng. Bulletin 219, New York (Cornell) Agricultural Experiment Station, 1904, pp. 181-182.

³ Rankin, W. H. Root Rot of Ginseng. Special Crops, n. s., vol. 9, June, 1910, p. 351.

⁴ Rankin, W. H. *Sclerotinia Panacis* sp. nov., the Cause of a Root Rot of Ginseng. Phytopathology, vol. 2, 1912, pp. 28-31, pl. 3.

attacked, its structure being completely disorganized and rapidly replaced by a dense felt of the black mycelium of the fungus. Black tuberlike sclerotia arise from this mycelium. These resistant masses live through the summer and in the autumn produce mycelium which spreads through the soil and infects healthy roots. The second spring after their formation they give rise to cuplike fruit bodies (Pl. X, fig. 4) which expand at the surface of the soil and discharge their spores into the air. These spores are carried by the wind to other parts of the garden, where they germinate and infect healthy roots. At least two ways are thus known by which this fungus may be disseminated. A peculiarity of the parasite is that it develops and produces the disease only during cold weather, i. e., in late fall, winter, or early spring. No further spread of the disease occurs after the plants come up.

Control.—When once established, the fungus may remain in the soil for several years, even where ginseng has not been grown meantime. A sharp lookout should be kept for the disease in the fall when digging and in the spring where roots fail to come up in the beds. All the black roots in the diseased area should be promptly removed and destroyed and the soil thoroughly disinfected with steam or formalin. (See page 40.) All tools used in digging and the shoes of the workman as well as his hands should be thoroughly disinfected with the formalin solution before going to other parts of the bed. Every precaution should be taken to avoid scattering infested soil or bits of diseased roots in other parts of the garden. No experiments for the control of this disease have been made in the field, and the foregoing suggestions are the best that can be offered with our present knowledge of the disease.

THE SPRAYING OF GINSENG.

The spraying of ginseng is to be practiced for the prevention of only such diseases as primarily infect the parts of the plant above ground. Those diseases which are now known to be more or less controlled by spraying are *Alternaria* blight, *Phytophthora* mildew, *Vermicularia* stem anthracnose, and *Pestalozzia* leaf anthracnose.

Fungicides.—Various fungicides have been suggested from time to time for the control of the different diseases of ginseng. *Alternaria* blight in particular has called forth many remedies warranted to control the disease, but Bordeaux mixture stands out from past experience as the most reliable. It has been repeatedly demonstrated that Bordeaux mixture (3-3-50) alone will control the *Alternaria* blight; hence, the necessity of adding arsenate of lead to the mixture is scarcely apparent. The sticking qualities of the mixture itself are sufficient to prevent its being washed from the plants and the

general absence of insect pests on ginseng makes unnecessary the addition of an insecticide.

The preparation of Bordeaux mixture is a very simple process. Copper sulphate (blue vitriol), costing 5 to 10 cents per pound, good stone lime (or good hydrated lime), costing about a dollar a barrel, and water are the materials used. These ingredients are to be put together in the following proportions: Copper sulphate 3 pounds, lime 3 pounds, and water 50 gallons, expressed by the formula 3-3-50. Other proportions may be used for some diseases and under certain conditions. Larger proportions of copper sulphate and lime are never necessary. Copper is the active fungicidal agent. The lime is added to neutralize the caustic action of the copper sulphate, which would otherwise burn the leaves of the plant.

The mixture is prepared by dissolving 3 pounds of copper sulphate in 25 gallons of water, suspending the crystals in a cloth bag just beneath the surface of the water, as the dissolved copper settles quickly to the bottom. The lime milk is prepared by slaking 3 pounds of stone lime with hot water, adding the water slowly so that the lime may crumble into a fine powder. When completely slaked, i. e., entirely powdered, cold water to make 25 gallons is added.

To prepare any desired amount of the Bordeaux mixture, the two solutions are thoroughly stirred and equal quantities of each are poured together into a third vessel or into a sprayer tank. If it is desired to add an insecticide, it is added at this stage. Arsenate of lead may be used, at the rate of 2 pounds to 50 gallons, or Paris green, at the rate of 1 pound to 50 gallons. Paris green is likely to cause burning; the arsenate of lead will not. The stock solutions of lime and of copper must be kept in covered vessels and thoroughly stirred each time before pouring together. They are good until used.

Two strong solutions should never be poured together and diluted afterwards. The two solutions should never be poured together until ready to use. It is well to strain the mixture as it goes into the sprayer tank, to take out anything that might clog the nozzles. Neither tin nor iron vessels should be used in making the mixture. It will never be necessary to add "stickers" of any kind to the Bordeaux mixture. It will adhere sufficiently of itself and will not wash off in rains.

It is usually desirable to test the Bordeaux mixture, to be certain that enough lime has been added to neutralize the copper sulphate. The ferrocyanid test is the most convenient and accurate. An ounce of yellow prussiate of potash (potassium ferrocyanid) is put in a pint bottle which is then filled with water. This is poisonous and should be so labeled. Into the mouth of the bottle a cork is placed, from one side of which a V-shaped piece has been taken so as to provide a small opening into the bottle. After adding the lime milk to the copper

solution, a few drops of the ferrocyanid solution are put into the mixture. If it turns brown there is still some free copper sulphate, and more lime must be added.

Lime-sulphur has been tried on ginseng to a limited extent but usually with disastrous results. Germination tests with spores of *Alternaria*, on glass slips sprayed with lime-sulphur of different dilutions, indicate that it is not effective at strengths that can be safely applied to the ginseng plant. Ginseng appears to be very susceptible to injury from lime-sulphur.

Growers will save themselves much expense and loss by using tried and proven fungicides. If failure to control the disease results when Bordeaux mixture has been used, the difficulty is to be sought elsewhere than in the fungicide.

Time of application.—Failure to apply the fungicide at the proper time is one of the chief causes of failure. In general, the following rules will be found effective: (1) Begin spraying as soon as the plants come up, avoiding applications just before freezing weather.¹ (2) Spray frequently enough to cover all parts of the growing plant as they are exposed. More frequent sprayings will be necessary during the growing period of the tops in the spring than later in the summer. (3) Apply the spray mixtures always just ahead of the rains, not just after. The spores of the disease-inducing fungi germinate and their germ tubes penetrate the host plant only during rainy, cloudy periods. Watch the weather map. (4) Important periods in the development of the plant are also to be taken into consideration in spraying, viz, when the plants are coming up and expanding; when the leaves and stems have fully expanded; just before the blossoms begin to open; just as the berries begin to enlarge; just before the berries begin to color. Applications made at these times to the parts of the plants indicated are likely to be most effective.

Thoroughness of application.—A few thorough applications are far more effective than many poorly made. From three to five timely applications thoroughly done should be sufficient in most seasons. It is not necessary to spray the under sides of the leaves. The stems and seed heads, however, should be thoroughly covered on all sides. Thorough work can be done only with a nozzle giving a fine mist, driven on the plants with high pressure. No pressure of less than 50 pounds should be tolerated. A hundred pounds is better. No machine at present appears to be entirely satisfactory for the spraying of ginseng, though several are made which will answer the purpose.

The philosophy of spraying.—Spraying is generally done as a preventive of disease, seldom as a cure. This fact especially applies to ginseng. The fungicide must be applied to the leaves, stems, etc.,

¹ Whetzel, H. H. Bordeaux Cold Injury of Ginseng during the Spring of 1907. *Special Crops*, n. s., vol. 6, pp. 184-187.

before the arrival of the fungous spores, at least before they germinate and initiate the disease. The fungus must be killed before it has entered the tissues of the plant, where the fungicide can not reach it. Little is to be expected of applications made after the disease has made its appearance in the plants, except to prevent further infection of healthy ones.

SOIL STERILIZATION FOR GINSENG.

It is well known that soil on which the same crop has been grown successively for several seasons frequently becomes unproductive. That this decrease in productivity in many places is due in considerable degree to the multiplication of certain pathogenic organisms, fungi or bacteria, is generally accepted. Such soils are often said to be "sick." Notable instances of such sickness are the flax-sick and wheat-sick soils of the Northwest and the tobacco-sick and cotton-sick soils of the South. It is not surprising, therefore, that in view of the many diseases seen to affect the roots of the ginseng plant, ginseng-sick soils should also be found; especially since ginseng is a long-time crop, remaining permanently in the same soil for at least three or four years. This unproductiveness of soils is often attributed to causes such as the exhaustion of fertility and the production of poisonous secretions from the roots of the crop grown on the soil instead of to pathogenic organisms in the soil. At any rate, sterilization of crop-sick soils has often proved highly profitable, and from the nature of the diseases attacking ginseng roots and the favorable results thus far recorded in the sterilization of ginseng soils, much is to be expected from this treatment in the future.

One of the most efficient and satisfactory methods of renovating crop-sick soils is rotation of the crops grown upon it. Unfortunately, this is not usually practicable in the case of ginseng. Some growers are practicing a rotation with golden-seal in their ginseng beds. This rotation has not been tried extensively enough to warrant conclusions. Sterilization, therefore, remains as the most practical method at present of renovating old ginseng soils. Aside from the destruction of parasitic fungi, sterilization often appears to actually increase the availability of food substances in the soil, the result being a marked increase in the growth of the crop.

The most practicable methods of sterilizing ginseng soils appears to be by the use of either formaldehyde or steam.

Formaldehyde.—The sterilization of ginseng beds with formaldehyde should usually be undertaken in the autumn, though it may sometimes be done in the spring. Remove the roots from the beds, throwing the soil up loosely. The drier the soil the better. Sterilizing the soil in a wet season presents many difficulties, especially where formalin is used. The formalin (which is the formaldehyde gas

dissolved in water) of a 40 per cent strength is diluted in water at the rate of 1 part of formalin to 100 parts of water. If the soil is quite wet the proportion of water should be reduced accordingly. Remember that the water in the soil will dilute the formalin. The grower must here use his judgment. In many cases a dilution of 1 part of formalin to 50 parts of water may be best. This solution (1 part to 100) should be applied to the soil at about the rate of 1 gallon to the square foot; less, of course, if the soil be wet and the solution stronger. It is best applied by one man either through hose attached to large tank or with a large watering pot, another workman spading the soil over as the solution goes on. It should be



FIG. 5.—Apparatus for steam sterilizing soil by the inverted-pan method.

pointed out that all beds treated with formalin should be first tile-drained, and the soil should not be worked after treatment until the excess water is well drained off. As soon as the soil will work without puddling, it should be again thrown up loosely to permit the evaporation of the formaldehyde. Ten days or two weeks after treatment, several respadings of the soil having been made, the beds should be in shape for replanting.

Steam sterilization.—Where a good steam boiler is available, steam may be used very effectively. The inverted-pan method devised by Mr. A. D. Shamel, of the Bureau of Plant Industry, appears to be the most practicable for ginseng beds. The apparatus (fig. 5) for

ginseng beds of the usual width should consist of a galvanized-iron pan, 4 by 10 feet and 6 inches deep, which is inverted over the soil to be sterilized, the steam being admitted through a steam hose connection in the end or side of the pan. The sharp edges of the pan which are forced down into the soil prevent the escape of the steam. The pan is fitted with handles for moving, and should weigh not more than 400 pounds. The soil is prepared as for planting. All fertilizers are applied and worked in as desired. A few potatoes are buried at a depth of about a foot to gauge the degree of heat attained. These should be cooked when sterilization is completed. The steam should be kept at as high a pressure as possible, 80 to 100 pounds, and the treatment should be continued for one to two hours, depending upon the pressure maintained. This treatment will destroy not only all fungous spores but weed seeds as well.

RELATION OF FERTILIZERS TO DISEASES OF GINSENG.

It is not the intention here to discuss the use or value of different fertilizers for the production of increased yields of ginseng. It is desired only to call the attention of growers to a few facts in regard to the effect on certain diseases of this crop of some substances which may be applied to the soil as fertilizers. But relatively little is known concerning this subject even as regards crops much older and more extensively studied than ginseng. We shall call attention only to some points on which we seem to have a little light.

Lime.—Lime has been widely used by growers on their ginseng beds. Many beds have been examined in which lumps of lime were still to be seen in the soil the second season after it had been applied, so heavy was the application. From the natural acid character of the woodland soil in which ginseng grows in a wild state, lime would seem of doubtful value to the plant under cultivation. Disaster in the form of the root-rust or fiber-rot has almost invariably followed its use. An alkaline condition is very favorable to the development of *Thielavia basicola*, the fungus believed to cause this disease. Lime applied to the soil brings about this alkaline condition. Its use on ginseng soil is to be avoided.

Wood ashes.—On account of the high percentage of lime which wood ashes contain their action in relation to root-rust or fiber-rot is much the same as that of lime, and their use is dangerous.

Acid phosphate.—One of the constituents of most commercial fertilizers is acid phosphate, to be had in the form of treated rock, i. e., containing phosphorous treated with sulphuric acid. It may also be had in the form of acid-treated bone. Its effect upon the soil is to bring about an acid condition which is unfavorable to the rust fungus¹

¹ Briggs, L. J. The Field Treatment of Tobacco Root-Rot. Circular 7, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1908, pp. 6-8.

and apparently favorable to the growth of ginseng. Hence, the application of acid phosphate (treated rock) is one of the most efficient means of combating this disease. The amount to be applied will depend upon the previous treatment of the soil; that is, whether limed or fertilized with ashes, etc. From 1,000 to 2,000 pounds of acid phosphate per acre have given good results in many places.¹ Where the soil from repeated applications of lime or ashes has become very alkaline it may be very unprofitable to attempt to remedy conditions by the use of acid phosphate. (See p. 31.) Where acid phosphate is used for this disease no nitrogen or potash is to be used with it.

Leaf mulch.—Very recently Mr. Frederick V. Coville, of the United States Department of Agriculture, has called our attention² to the fact that ordinary oak or maple leaves when freshly fallen contain a large proportion of acid which rapidly leaches out of the leaves with the rains of fall and winter. He has suggested the possibility of bringing about an acid condition of the ginseng beds by the use of a mulch of oak or maple leaves applied as soon as they fall in autumn and removed early in the spring before they can interfere with the coming up of the plants. Extensive experiments to test this suggestion are now under way, but no results can yet be reported.

Nitrogenous fertilizers.—An excessive use of nitrogenous fertilizers appears to be responsible very frequently for a serious leaf injury. (Pl. XII, fig. 3.) This injury has been many times observed and in certain places it was clear that heavy applications of nitrate of soda to the soil the previous autumn were responsible for it. In other cases the evidence carefully gathered and studied indicated that heavy applications of barnyard manure had produced the injury. Similar injury from the use of hen manure on the beds is reported. A light mulch of manure, even fresh manure, applied in the fall does not appear to be dangerous.

DRAINAGE OF GINSENG BEDS.

In a number of connections the necessity for artificial drainage in the cultivation of ginseng has been already pointed out. Drainage consists essentially in the removal of excess water from the soil in the root zone. When plants are growing naturally in the forest the excess water in the soil is removed by the roots of the trees and shrubs. Under cultivation some artificial means of removing this excess of water from the beds must be employed. The means best adapted for ginseng gardens is some type of underground channel. Open drains, usually the paths, are not efficient and are not to be

¹ Whetsel, H. H., and Osner, George. The Fiber Rot of Ginseng and its Control. Special crops, n. s., vol. 9, 1910, pp. 411-416.

² In a letter dated October 27, 1911.

depended on. Many materials may be used for these underdrains, but the ordinary hard-burned clay tiles have proved most effective and permanent. Cement tiles now coming into use are also very satisfactory.

Depth, frequency, and size of drains.—The drainage method must vary with the character of the soil, subsoil, and the character and amount of the rainfall. Since water percolates so much more readily through sand and gravel than through clay, drains should be placed much deeper in the former (3 to 4 feet) than the latter (1½ to 2 feet). The lines of tiles should be placed from 6 to 8 feet apart and where possible under the center of the bed. The size of the tiles depend upon the volume of water to be handled and upon the slope of the land or gradient. In general 3-inch tiles will be found satisfactory.

In the construction of a tile drain the grower should take special precaution in regard to a number of points. Some of these points are as follows: (1) So far as possible the drain should run with the slope of the land, the fall being as great as the nature of the land will permit having the gradient uniform. (2) The outlet should be well protected against the entrance of small animals. (3) The joints should be fairly close, a feature that can best be attained by the use of hexagonal tiles.

Effect of drainage.—The tile drain will not only remove the excess of water from the root zone and in this way make the roots less liable to the attacks of certain parasitic organisms, but will affect the roots in a number of other ways. Among the most important of these effects are the following: (1) It improves the aeration. This result comes from the granulating effect of the removal of the excess water, allowing a better circulation of air through the soil. The roots of plants require the oxygen of the air just as do man and other animals. Oxygen is also necessary for the growth of favorable soil organisms. (2) Drainage raises the average temperature of the soil. It is well known among growers that a wet soil is a late soil, while a well-drained soil is much earlier in attaining the temperature necessary for the germination and growth of plants. In other words good drainage lengthens the growing season. (3) Drainage will reduce heaving which results from the freezing of wet soils. In the opinion of many growers heaving is responsible for much injury to seedlings.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 251.

B. T. GALLOWAY, *Chief of Bureau.*

THE PECAN.

BY

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Field Investigations in Pomology.*



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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., March 20, 1912.

SIR: I have the honor to transmit herewith a paper entitled "The Pecan," by Mr. C. A. Reed, Special Agent in Nut-Culture Investigations, prepared under the direction of Mr. A. V. Stubenrauch, Expert in Charge of Field Investigations in Pomology.

I recommend that this paper be published as Bulletin No. 251 of the Bureau series.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

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THE PECAN.

INTRODUCTION.

The pecan is one of the most important of the nut-bearing trees now grown in the United States, and within the area thought to be adapted to its culture no other agricultural or horticultural product which has appeared during recent years is attracting greater attention or being so widely exploited. It was not found by the early botanists nearer the Atlantic coast than western Alabama in the South and central Tennessee and Kentucky in the North, but with the progress of agriculture in the South the species has been carried eastward and widely distributed with apparent success over the eastern Gulf and South Atlantic States. It has also been sparingly introduced into many of the Northern States, including Ohio, Michigan, New York, Pennsylvania, Maryland, Delaware, New Jersey, and to a slight extent into the lower New England States. In the West it has received but little attention. A few planted trees may be found here and there from Washington to southern California, but pecan growing has not become an important industry west of the Rocky Mountains.

The evident age of not uncommon large trees near the Gulf coast indicates that the planting of pecans in the Southern States east and south of the area of the natural range of the species has been in progress for more than a century. The planting of orchards in those States began with seedling trees about 20 years after the Civil War. During the early nineties grafted and budded trees of named varieties appeared in sufficient numbers so that a few orchards of such trees were then planted, but comparatively few orchards of either seedling or grafted trees were planted previous to 1900. Since that time, especially during the past five years, the planting of pecan orchards in the Southern States has been taking place at a rapidly accelerating rate. In southern Mississippi, southern Alabama, central and southern Georgia, and northern Florida, large tracts of land, frequently several hundred acres in extent, are being planted to pecan trees and later sold to outside investors. For several years the demand for nursery-grown trees has been far beyond the supply, leading nursery-

men booking orders for their entire output from six to eight months before the planting season. Most unusual interest is being manifested in pecan culture, and investments, which are large for an industry that is still in its infancy, are being made in spite of the fact that very few pecan orchards are as yet of sufficient age to have been in bearing long enough to furnish reliable data upon which to make safe estimates as to the probable yields of a given variety at any stated age in particular localities. Observations, accurate in themselves, on the bearing records of single trees here and there are frequently taken as the basis for estimates as to the probable yield of an entire orchard of the same variety or varieties, but as it usually develops that the trees making these records have grown under conditions of exceptionally favorable environment, the fallacy of such calculations is at once apparent. To be at all trustworthy, estimates as to future yields must be based on the average records of a great number of trees under normal conditions rather than of single trees which are conspicuous because of their abnormal production.

An erroneous impression to the effect that the pecan has no serious enemies in the way of insect pests or fungous diseases and that it is not affected by drought, freezing temperatures, or high winds has become prevalent among a considerable portion of prospective commercial and amateur planters. No agricultural product is without its natural enemies and other obstacles that must be overcome. When any plant is brought under cultivation and large contiguous areas are planted, the opportunities for the development and spread of the insects and diseases attacking it are greatly increased. The pecan is no exception to this rule, and in due time many serious enemies to it must be expected to appear. Among the insects that have already appeared are those which attack the fruit buds in early spring; girdlers which cut off the twigs during the latter part of the growing season, frequently causing branches with clusters of nuts to fall to the ground; webworms which defoliate the trees; shuckworms which destroy the nut by burrowing out the soft hull while immature; weevils which work in the nut itself; and borers which penetrate the body and main branches of the tree; besides a number of others less well known. A large number of fungous diseases also attack the pecan. The most important of these diseases is the pecan scab, which attacks the foliage, stems, and hulls of the young nuts of mature trees and which is sometimes very serious on late, rapidly growing trees of certain varieties in the nursery.

Investigations of the control of insects and fungous diseases attacking the pecan are receiving the attention of other investigators; a detailed discussion of these problems is therefore beyond the scope of this bulletin, which is designed to give such general information

concerning the various phases of the pecan and its culture as is available at the present time.¹

Long-continued rains at the blossoming time which interfere with pollination, late spring frosts which kill the buds or destroy the young nutlets, sudden drops of temperature in winter during which immature late growth may be severely frozen back, subtropical storms of such intensity as to blow the nuts off and sometimes to uproot grown trees, and droughts during the late summer months just as the nuts are maturing are inevitable obstacles which must be taken into consideration.

BOTANICAL CLASSIFICATION OF THE PECAN.

The pecan is an American species of nut-bearing tree belonging to the botanical family Juglandaceæ, which includes also the hickories, the walnuts, and the butternut. It has been variously known as *Juglans pecan*, *Carya olivaeformis*, and by other less common terms. The botanical name now commonly accepted is *Hicoria pecan*.

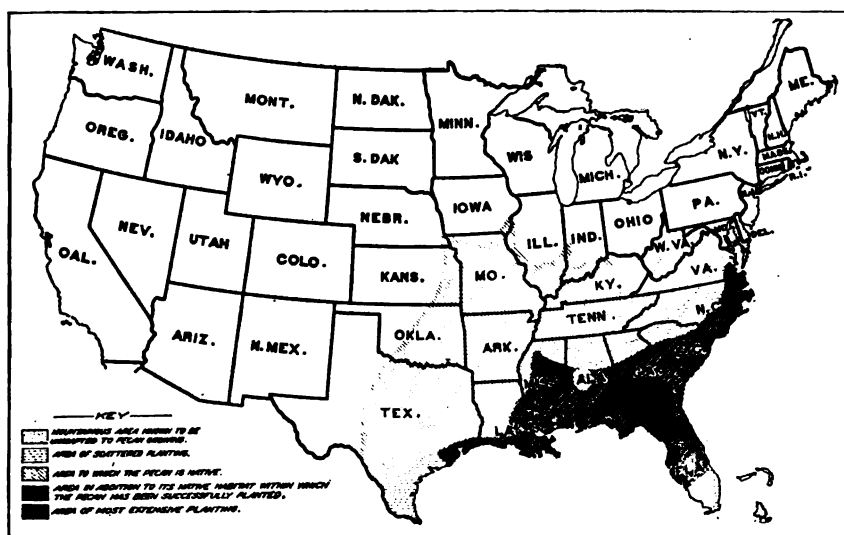


FIG. 1.—Outline map of the United States, showing the range of the pecan exclusive of occasional plantings in the Western States and scattered trees throughout the West and North.

NATURAL DISTRIBUTION.

The pecan is wholly an American species found only in certain parts of the United States and Mexico. Figure 1 is an outline map of the United States showing areas within which the pecan occurs at the present time. From this map it will be seen that with the

¹ All inquiries addressed to this Department relating to the matter of insect pests should be directed to the Chief of the Bureau of Entomology, and those regarding diseases to the Pathologist in Charge of Fruit-Disease Investigations, Bureau of Plant Industry.

exception of a small area ¹ in central Alabama, west of Montgomery, the eastern boundary of the pecan habitat is marked by an irregular line drawn southward across central Kentucky to central Tennessee;



FIG. 2.—A large pecan tree in Ascension Parish, La., having an estimated height of 130 feet, a spread of 125 feet, and measuring 18 feet 3 inches in circumference at breast height.

thence south and west to near central northern Mississippi, and southwest to central southern Louisiana; from this point the line

parallels the border of the Gulf of Mexico to southern Texas without reaching the coast. In a line nearly parallel to that of the eastern border, the western boundary extends from southwestern Iowa across eastern Kansas, western Oklahoma, and western Texas to the Rio Grande.

HABIT OF GROWTH.

In habit of growth the pecan varies greatly, according to environment and locality. Under the most favorable conditions it develops a massive spreading top in the open, while in thickly crowded forests it attains great height. In the alluvial lands of the Mississippi River bottoms specimen trees ranging from 4 to 6 feet in diameter



FIG. 3.—A native forest cleared of timber other than pecan on the Kentucky side of the Ohio River, 10 miles from Evansville, Ind.

and from 150 to 170 feet in height are not uncommon. Figure 2 shows a pecan tree in Ascension Parish, La., photographed in 1909, having an estimated height of 130 feet, a spread of 125 feet, and measuring 18 feet 3 inches in circumference at breast height. A view of a native forest cleared of all timber other than pecan, situated on the Kentucky side of the Ohio River not far from Evansville, Ind., is shown in figure 3. Pecan trees having diameters of 2 to 4 feet and heights of 75 to 100 feet are not uncommon in this forest.

In the semiarid sections of Texas the growth is different from that of humid regions; the trees do not attain such great size, their

bodies are shorter, the limbs more irregular, and the terminal branches much more willowy. An illustration of the characteristic growth in that section is shown in figure 4, reproduced from a photograph taken in Landa Park, New Braunfels, Comal Co., Tex.¹

FLOWERING HABIT.

The pecan tree has alternate pinnate leaves, with from 11 to 17 leaflets each; the flowers are monœcious, i. e., the staminate and pistillate blossoms are borne separately upon the same tree. The staminate blossoms appear in clusters of catkins upon the last season's growth somewhat in advance of the pistillate blossoms, which



FIG. 4.—Characteristic pecan trees of Texas. Photographed in Landa Park, New Braunfels, Tex., 1910.

are found only at the terminals of the new branches. A cluster of pecan foliage illustrated in figure 5² shows the arrangement of floral organs. The catkins are to be seen as pendulous clusters suspended from the growth of the past season. The pistillate flowers are somewhat obscurely shown at the point of termination of the new growth. A section of a catkin is shown at *a* and of a pistillate flower at *b*, both greatly enlarged.

¹ These trees are draped with "Spanish moss" (*Dendropogon usneoides*), a pendulous, beardlike air plant of gray color which attaches itself to the branches of many species of trees in the South. This moss is not a true parasite, as it obtains no food from its host; but if neglected after it has established itself on pecan trees it is liable to become a serious pest, as it covers the branches to such an extent as effectively to smother the bearing area.

² The drawing was made very early in the growing season, before the normal number of leaflets had appeared. The staminate bloom is in somewhat greater profusion than the average for the variety shown, which is the Van Deman.

DECREASE IN NUMBER OF NATIVE TREES.

The normal clearing of forests in any community during its agricultural development, the increased use of pecan timber for hard-wood manufacturing purposes, and the extravagant habits of cutting out the tops at harvest time and of chopping down the trees altogether in order more easily to obtain the nuts, practices which prevail in many sections, have combined seriously to reduce the number of pecan trees in the native forests. The first two causes can hardly



FIG. 5.—Pecan foliage and flowers. *a*, Section of a catkin (staminate flower cluster); *b*, pistillate flower.

be prevented, and it is doubtful whether the latter practices can be checked until the finest specimens have entirely disappeared.

CULTURAL DISTRIBUTION.

East of the Mississippi River and its northern tributaries the pecan has been introduced into a majority of those States to which it is not native, but it is only within certain localities that the species has thus far indicated its probable commercial adaptability. With the

exception of the native trees occurring in western Kentucky, southern Indiana, southern Illinois, southeastern Iowa, and eastern Missouri, pecan trees are not found in considerable numbers north of the latitude of lower Virginia. It does not adapt itself to mountainous sections or to lowlands in which standing water is found on or near the surface for protracted periods. Few plantings have been made below central Florida or in mountainous areas, but with these exceptions representatives of the species are not uncommon over any large area in the southeastern quarter of the United States. Certain localities are undoubtedly better adapted to pecan culture than others, but in the present infancy of the pecan industry it is too early to name the most favorable sections. Orchards already planted are mostly found within a few comparatively small areas, a fact which is without doubt largely due to the common tendency of a community to follow a leader, which in this instance has been in the matter of planting pecan trees, rather than to established proof of special adaptability of the particular locality. The areas of most extensive plantings are indicated by the gradations in shading shown on the outline map (fig. 1).

EXTENT OF PLANTING.

During the winter of 1908 an inquiry was made by the Bureau of Plant Industry regarding the pecan orchards then in existence. Replies were received covering about 600 orchards situated in various portions of the South. These reports show a total of nearly 300,000 trees then under cultivation. More than two-thirds of these trees, viz, 209,069, were of named varieties (including both nursery-grown and top-worked trees), 39,839 were seedlings of known parentage, and 45,086 were from seed of unknown origin.

Of the named varieties, 175,126, or nearly seven-eighths of the total number reported, were located in 10 States, as shown in Table I.

TABLE I.—*Distribution of plantings of named varieties of pecan trees in different States.*

State.	Number.	State.	Number.	State.	Number.
Florida.....	48, 475	Alabama.....	20, 694	North Carolina.....	966
Georgia.....	32, 990	Texas.....	12, 894	Oklahoma.....	908
Louisiana.....	27, 507	South Carolina.....	2, 957		
Mississippi.....	25, 449	Virginia.....	2, 286	Total.....	175, 126

While these figures do not cover the whole area then devoted to pecan culture, they probably indicate the proportional planting in each State.

It has been recently estimated¹ that approximately 1,400,000 trees have been sold from the nurseries during the past five years, or

¹ Letters from leading nurserymen received during February and March, 1911.

from the season of 1906-7 up to and including that of 1910-11. These sales appear to have been distributed among the principal pecan-growing States in much the same proportion indicated by the figures in Table I.

ECONOMIC IMPORTANCE.

The figures of pecan production of the census for 1910 have not yet been published, but from estimates¹ made by a number of the leading wholesalers of pecans the annual crop in the State of Texas alone during the past five years has ranged from 135 to 660 carloads, or from 3,645,000 to 17,820,000 pounds.² The prices to the producer have ranged from 4 to 16 cents per pound. During the past five years the average midseason price has been from 7 to 9 cents a pound. Estimates derived from the same source indicate that, beginning with Louisiana, next to Texas in quantity of production, and ending with Indiana and Illinois, each producing about 10 cars, the remainder of the average crop is apportioned among the other pecan-producing States in about the following order: Louisiana, Oklahoma, Arkansas, Kansas, Missouri, Kentucky, Tennessee, Mississippi, Indiana, and Illinois.

Commercially speaking, orchard-grown pecans have not yet been produced in sufficient quantities to affect the general market to an appreciable degree. The demand for pecans of the named varieties created by nurserymen for use as samples, or by fancy confectioners, tourists, and occasionally by seedsmen has caused a very wide range in prices, which can not be expected to reach a normal basis until the cultivated pecans reach the general markets in sufficient quantity to compete fairly with wild nuts.

Among the nuts exported from this country the pecan is of relatively small importance and is not separately listed in the Government reports. According to the annual reports of the Department of Commerce and Labor, the importations of pecans from Mexico, first separately listed in 1908, are shown in Table II.

TABLE II.—*Importations of pecans from Mexico into the United States for the fiscal years 1908 to 1911, inclusive.*³

Fiscal years, ended June 30.	Quantity.	Value.
	<i>Pounds.</i>	
1908.....	1, 118, 071	\$82, 181
1909.....	1, 480, 289	106, 298
1910.....	3, 349, 460	232, 590
1911.....	2, 333, 067	158, 812

¹ Letters received during the month of February, 1911.

² A carload of pecans weighs from 24,000 to 35,000 pounds.

³ A duty of 1 cent a pound has been levied upon all pecans thus far imported.

CULTURE.

PRESERVATION OF NUT-BEARING FORESTS.

The value of pecan-producing forests is coming to be recognized to such an extent that at the present time certain enterprising owners are not only taking steps to prevent their further destruction but are increasing their productiveness by a careful and systematic elimination of all unprofitable trees, so as to give greater advantage to such as produce superior nuts.



FIG. 6.—A pecan forest near San Antonio, Tex., in process of transformation into a grove by the elimination of all trees other than the most desirable pecans. Note the distances between trees.

This work is well worthy of encouragement. As clearing too suddenly will expose the remaining trees to injury by high winds, the thinning-out process should be brought about gradually. The least desirable pecan trees should be marked during the harvest period and subsequently removed. In clearing such tracts the owner should keep in mind the best methods of converting the forest into an orchard. Trees which produce the best nuts in the greatest quantity should be the ones allowed to remain. As far as possible the low-headed trees should be given preference. Pruning, having in mind the cutting back of long, spindling branches and the removal of

broken tops, will have a decidedly beneficial effect. As the new tops begin to take definite form in later years, further improvement by elimination should continue. The owner must decide for himself regarding the advisability of top-working any or all trees.

When two trees of equal merit (so far as quality of nuts, regularity of bearing, health, and apparent condition of the trees are concerned) crowd each other, preference should be given the one which releases its nuts from the hulls with the greater readiness. If one is more subject to fungous diseases or to ravages of insect pests than the other, it should be removed. Vacant spaces in the wood lot should be filled in by planting nuts from the best trees or, better still, by transplanting. Any attention to cultivation, irrigation if necessary, or the application of compost should result in an increased production of nuts. A pecan forest near San Antonio, Tex., treated in the manner just described, illustrating what can be done, is shown in figure 6.

SOIL AND MOISTURE REQUIREMENTS.

In its early history the pecan was thought to be severely exacting in its requirements of soil and moisture conditions and in the essentials for successful propagation. Since becoming better known, however, it has been found that while certain conditions may be most conducive to good results, the pecan adapts itself to varying environment to such an extent that it has been planted with apparent success in a great variety of soils in the Southern States. Ideals are constantly changing as experience is gained, but in the light of present knowledge a deep, fertile soil, sufficiently porous to admit of free root growth, well drained yet by no means dry, is considered as being best adapted to pecan culture. Localities in which the water table below the surface is within reach of the taproot seem to be preferred by the pecan. This fact is of such common belief with the well drivers of the semiarid portion of Texas that they seek proximity to pecan trees when boring for water. It is essential that the trees should not be allowed to remain in standing water for any great length of time, although an occasional overflow to a depth of several feet apparently does no harm.

HISTORY OF PROPAGATION AND PLANTING.

Less attention has been paid to planting the pecan in orchard form in regions where it abounds as a forest tree than in many of the neighboring localities of nearly similar soil and climatic conditions. It seems to have been understood by certain pecan-growing pioneers previous to 1850 that the species did not come true from seed, but that information was not general until a half century later.

Practically all pecan orchards planted were of seedling trees. History¹ records that in 1846 or 1847 a slave gardener, Antoine by name, instructed by his owner, Telesphore J. Roman, succeeded in grafting 16 trees of the variety which later came to be known as Centennial. Subsequently 110 trees were similarly propagated by the same individual, bringing the total number known to have been grafted before the close of the Civil War (1865) to 126.

There is little evidence of further propagation by this method until 1877,² when Emil Bourgeois, of Union, La., successfully grafted 11 scions of the variety now well known as Van Deman, but then called the "Duminie" or "Duminie Mire," in honor of its owner. The Frotscher and Rome varieties were propagated by Richard Frotscher, of New Orleans, in 1882, as was the Stuart by the late A. G. Delmas, of Pascagoula (formerly Scranton), Miss., in 1886. Aside from these records there is little in pecan history to indicate that much was accomplished in the way of propagating the species other than by planting the seed until the early nineties, when grafting of named varieties came to be a matter of common practice with certain growers in southern Mississippi, Louisiana, and Texas. The limited number of superior parent trees from which to obtain grafting wood, the small degree of success then obtained with that method of propagation, the consequent high prices of nursery trees, together with the ignorance and doubt in the public mind regarding the certainty of grafted trees, resulted in the continued planting of nongrafted trees for the next decade. During the years 1900 to 1905 the fact of the very great dissatisfaction so certain to result from the planting of seedling trees came to be well known, and since then few trees of nongrafted stock have been planted.

PROPAGATION.

SELECTING SEED FOR PLANTING.

Until comparatively recent years very little attention has been paid to the selection of seed for nursery planting other than to obtain cheap nuts of high germinating quality. No thought has been given at the time of selecting the seed to the subsequent growth of the trees, and as a result there has been a conspicuous lack of uniformity in the rapidity of growth both in the nursery and in the orchard. While no one has compared the later behavior of trees which grew slowly in the nursery, when transferred from the nursery to the orchard, with the behavior of those which grew more rapidly as seedlings, it is logical to suppose that the degree of vigor is proportionately

¹ Yearbook, U. S. Dept. of Agriculture, for 1904, p. 407.

² Yearbook, U. S. Dept. of Agriculture, for 1904, p. 415.

the same. It is generally conceded by nurserymen in north Florida and in south Georgia, where by far the greater portion of all nursery pecan trees are grown, and by certain nurserymen in Louisiana who are known to have made the comparison, that pecan seed from Louisiana germinates more slowly and makes slower growth than does seed from the East. For this reason Florida and Georgia seed is commonly used by southern nurserymen.

Recent experience in north Florida and south Georgia in the South and in lower Virginia farther north has convinced the nurserymen in those localities that southern seedlings are undesirable as stocks for northern scions, and vice versa, in that, owing to the difference in time of starting in the spring and maturing in the fall, neither of the two makes a satisfactory growth when grafted or budded on the other.

Experience shows that for seed purposes plump nuts of medium size should be selected from vigorous-growing and productive trees as nearly free from disease as it is possible to obtain. As already indicated, it is also evident that seed from north Florida and south Georgia is preferable for use in the Gulf Coast States from Florida to Louisiana and that in the selection of seed for any locality the influence of latitude should be kept in mind.

STRATIFYING PECAN SEED.

Pecan nuts to be planted as seed should be retained in as nearly as possible their original condition at the time of harvest. If allowed to become dry they should be thoroughly soaked before planting. If the nuts are to be held for a period of several weeks or during the fall and winter for spring planting they should be stratified as soon as practicable after harvesting. "Stratification" is the technical term for the method of packing the nuts in moist sand and keeping in a cool, dark place to prevent evaporation or germination by combined warmth and moisture. To protect the nuts from rodents, the box or boxes in which the nuts are kept should be covered with wire screen. Proper drainage must be assured.

PLANTING PECAN SEED.

The planting of pecan seed may be performed soon after harvest or early in the spring. Fall planting does away with the need of stratifying, but encounters the risk of loss by winter injury and depredations of field mice and other rodents.

Germination is earlier and growth quicker in sandy soils than in heavy soils. Proper drainage is also more easily assured in sandy soils, and for these reasons light soils are ordinarily preferred for nursery purposes. Irrespective of its nature, the land should be

thoroughly prepared before the seed is planted. The soil should be fertile, well cultivated, and yet firm. Plant the nuts 2 to 3 inches deep and 8 to 12 inches apart in rows 4 to 6 feet apart; cover with loose, fertile soil, and pack firmly. A top-dressing of leaf mold or other light compost 1 or 2 inches deep will aid greatly in keeping the surface mellow and moist.

During the first season the growth will be largely confined to the development of a taproot, which will be from 3 to 5 times the length of the top. In ordinary seasons the growth above ground will be from 6 to 12 inches.

A method occasionally followed is to plant half a dozen nuts in the permanent location where the tree is to stand. Later the best one of the resulting trees is grafted with the desired variety, and the others are cut away. This method avoids the labor and expense of transplanting. In actual practice, however, this method has thus far rarely proved satisfactory. On the contrary, the claim is made by several of the more experienced growers that transplanting pecan trees results in more compact and fibrous root systems and is therefore a positive advantage. Unless protected by heavy stakes, the young trees under these conditions are subject to injury by careless workmen. Moreover, it frequently happens that none of the nuts planted produces a tree fit for grafting. It is therefore doubtful whether this method of establishing an orchard can be commended.

COMPARISON OF SEEDLING AND GRAFTED TREES.

As has been previously explained, no matter how carefully the seed may be selected, pecans grown from the nuts do not reproduce themselves true to the parent type. Of all the trees observed in past experience with the pecan not a single authentic instance is on record in which a tree grown from the nut has been identical with its parent or any of its sister seedlings. Whenever it is desired to perpetuate definite varietal characteristics of the pecan it must be done by asexual methods of propagation, i. e., by grafting or budding. In contradiction to this, certain tree dealers have recently advanced the claim that grafted and budded trees are proving unsatisfactory, asserting that they are shorter lived and more subject to disease than seedlings; that they are otherwise objectionable and are consequently being discarded. Evidence to support the claim that the operation of either grafting or budding, when successfully performed, has any effect whatever upon the longevity of the tree or its susceptibility to disease is entirely lacking. Healthy grafted and budded trees of all ages up to 30 years since the operation was performed are sufficiently common throughout the pecan area entirely to dispel all doubt as to the enduring qualities of trees

so propagated. Statements to the opposite effect are made evidently for the sole purpose of selling inferior seedling trees.

As ordinarily only such sorts as are especially productive or otherwise superior to the average are commonly perpetuated by asexual propagation, a belief has become more or less prevalent that in some way the operation in itself is responsible for the productiveness. This is a mistaken view, as the scions and buds only perpetuate such characteristics as they inherit from the parent tree. Wood of the previous season is preferable for grafting and should be taken only from the very best and most carefully selected parent trees.

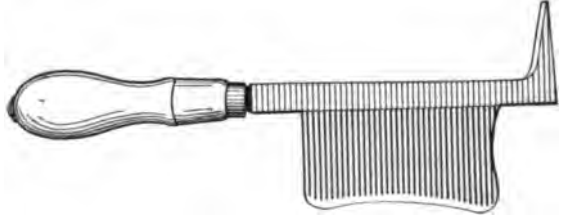


FIG. 7.—A tool especially designed for cleft grafting.

CLEFT GRAFTING.

In its modifications grafting has been longer employed than budding. It is performed during the late winter months just as the buds begin to swell, or very early in the growing period. At that time the upward flow of sap is most rapid and the union will be accomplished most quickly. Scions for any kind of grafting should be selected from the growth of the last season. Terminal twigs were formerly used almost exclusively and are still preferred by some propagators. But, as the bud at the end of the branch rarely produces a strong shoot, ordinarily drying up and falling off instead, terminal twigs are no longer used to a large extent.

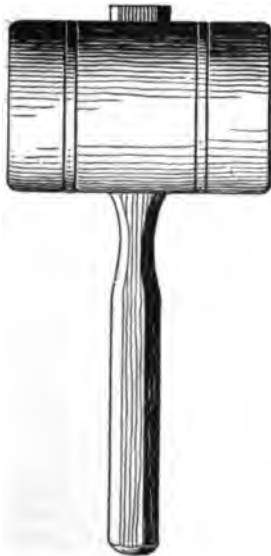


FIG. 8.—Mallet for use in cleft grafting.

A well-filed fine-tooth saw, a sharp grafting knife, a specially devised grafting tool (fig. 7), a short-handled wooden mallet (fig. 8), a quantity of raffia and grafting wax or grafting cloth, and a number of scions constitute the necessary equipment for grafting.

In performing the operation of cleft grafting, the trunk or limb of the tree to be grafted (technically known as the stock) should be cut squarely across with the saw; the knife edge of the grafting tool should then be placed across the stock, either over the center or to

one side in order to avoid the pith, and by tapping the back of the tool with the mallet split or, better, cut the stock to a depth of 2 to 4

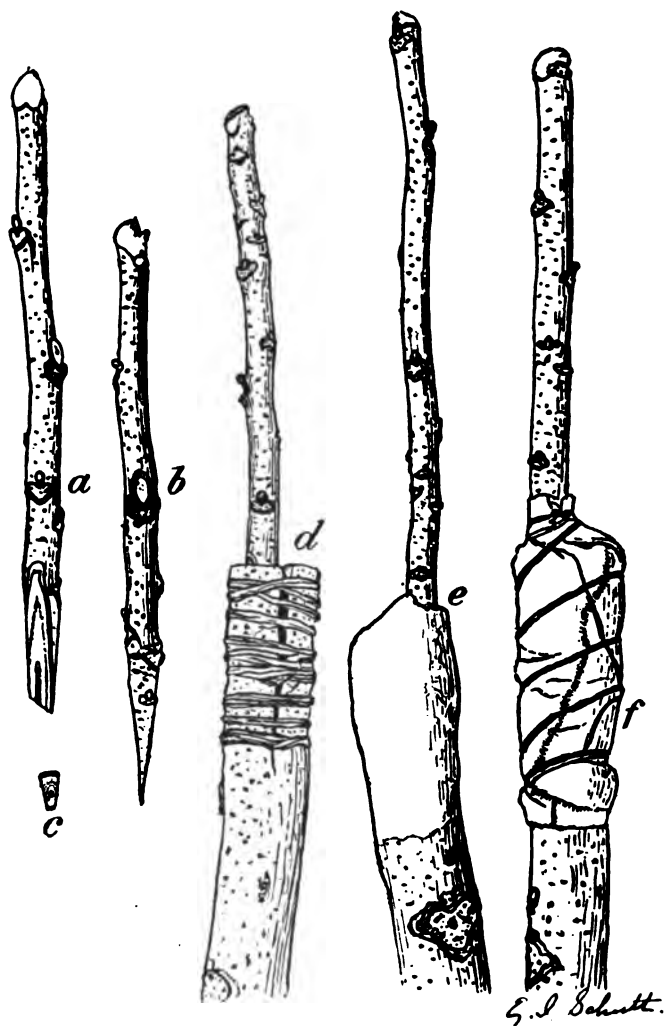


FIG. 9.—Cleft grafting. Successive steps in the operation: a and b, Views of the scion; c, cross section of the scion, thicker on one side; d, the scion in place and the stock securely tied to prevent splitting; e, the union covered with grafting wax; f, outer wrapping securely held with string.

inches. Remove the tool and pry the two parts of the stock apart with the thick, narrow wedge projecting from the back of the graft-

ing tool at the extreme end. Prepare the scion by sharpening its lower end with the grafting knife into the form of a wedge (fig. 9, *a* and *b*) made thicker on the side which will be outermost when in position (fig. 9, *c*). Insert the wedge end of the scion in the cleft of the stock so that the cambium layer (inner bark) of its thick side will be in close contact with the inner bark of the stock. The scion should be pushed into the cleft until the cut surface of the stock is on a level with the base of the first bud. It will do no harm if it goes slightly deeper. It is imperative that the two cambium layers be brought together as closely as possible. With stocks of sufficient size a second scion may be similarly placed in the opposite end of the cleft. Remove the iron wedge from the middle of the cleft and cover the cut surfaces, including the tip of the scions (unless terminal shoots have been used), with grafting wax especially prepared, being careful not to cover the buds. If the stock is weak and inclined to further splitting, after the wedge has been removed it should be tightly wound with several wraps of a stout, rather coarse material before the wax is applied. Where a large amount of grafting is to be done, the best as well as the cheapest material for wrapping is a product of one of the eastern tropical palms, known as raffia, which is obtainable from dealers in nursery supplies. For propagation on a small scale, cotton warp, strips of old muslin, or similar material will answer fully as well.

FORMULAS FOR GRAFTING WAX.

(1) Mix together thoroughly 4 parts (by weight) rosin, 2 parts beeswax, and 1 part tallow.

(2) A harder wax for use in warm weather is made of the following: Rosin, 4 pounds; beeswax, 1 pound; raw linseed oil, one-half to 1 pint.

To prepare either formula melt the ingredients together, pour into water, and pull. Rub the hands with oil or grease before using to prevent sticking. In using the second formula the proportion of oil will depend upon the season, a greater quantity being necessary in cooler weather.

PREPARATION OF GRAFTING CLOTH.

Thin calico or cheap muslin saturated in melted wax, drained, and allowed to cool makes a material which answers both as a wax and as a binding substance. Before immersing in the liquid, tear the cloth into strips 12 to 18 inches wide or of whatever width may be most

convenient. When thoroughly saturated take it from the solution and while still warm remove the excess of hot wax. Various methods of accomplishing this removal are practiced. On a small scale the cloth may be wrung out with the hands, but when larger quantities of material are to be made a convenient method much in use is to draw the cloth between two flat pieces of wood. A simple method is certain to suggest itself to any ingenious operator.

When grafting cloth of the proper consistency is used raffia will be unnecessary, as the properly prepared material carefully wrapped holds itself in place without being tied.

CARE OF CLEFT GRAFTS.

Obviously, two scions placed in one cleft double the chance of success. With an ordinary wrapping of waxed cloth further attention to the graft itself will not be needed. If wound with stout material the bandages should be severed as soon as growth has begun, when the weaker of the two scions should be cut away. If both scions are allowed to remain, the formation of a fork between the two will be inevitable and splitting very apt to follow. A single scion affords a much better opportunity for the development of a symmetrical head and there is less danger of crowding than when two scions are left.

WHIP GRAFTING.

The operation of whip grafting is usually performed during the latter part of the dormant season, at any point in the trunk from immediately below the surface to several inches underground. For this method of propagation the stock and the scion should be of very nearly the same size, preferably not more than three-fourths of an inch in diameter nor smaller than a lead pencil. With the knife held so as to make an upward incision, cut the stock entirely across at a long angle, as shown at 1 in figure 10. At about one-third the distance from the upper end of the cut make an incision parallel with the grain, as shown at 2 (fig. 10). Cut the scion at as nearly the same angle as possible and make a similar incision in the cut surface one-third the distance from the upper end of the cut, as shown at 3 (fig. 10). Push the cut surfaces together in such a way that the tongue of the scion made by the incision will be crowded into the groove made by the incision in the stock, as shown at 4 (fig. 10). Bind the two parts together with raffia or other material, as shown in figure 11 at *a* (not as appears at *b*), and pack firmly with earth. The use of wax is not necessary.

CARE OF WHIP GRAFTS.

When grafted by the whip-graft method the young trees will require little subsequent attention other than pruning and ordinary cultivation. When the root is that of a very young tree there will be no danger of the supply of plant food being such as to induce a growth of top that is too rapid, as is frequently the case with cleft grafts, especially in the tops of old trees. While temporary staking as a support to the union is not necessary, in numerous cases stakes will be highly essential to insure erect growth. The moisture of the ground causes the wrapping material to decay in the course of a few weeks, and it is therefore not necessary to cut the bands, as with cleft grafts.

BUDDING BY THE ANNULAR METHOD.

It is probable that more pecan trees have been propagated by annular budding, with its modifications, than by all other asexual

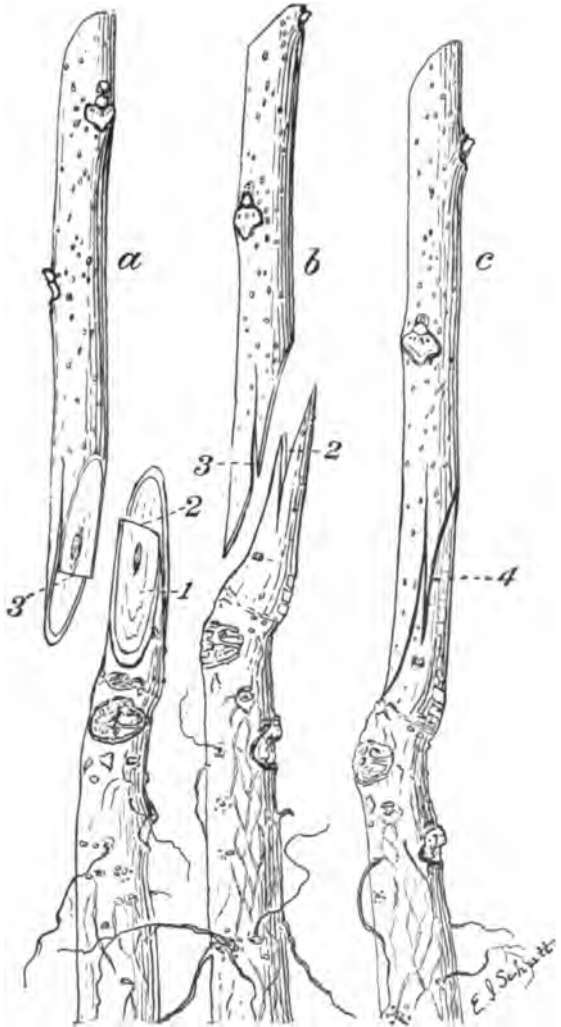


FIG. 10. —Whip grafting. Early steps in the operation: *a* and *b*, Front and side views of both stock and scion properly cut; *c*, stock and scion in position and ready for wrapping.

methods combined. The process is also known as “ring” and “flute” budding. It is performed during the midsummer months at such time as the bark is found to slip (release) most readily. In some seasons this period may be very brief, lasting only a few

days, while in other years the time during which annular budding may be successfully performed extends over a period of several months. In the latitude of southern Georgia it is not uncommon for this method to be successful from as early as May 10 until late in July or even in August.

Annular budding consists merely in transferring a ring of bark to which is attached a bud of the desired variety from a bud stick¹ to the trunk or branch of another tree in place of a similar ring of bark previously removed. Specially designed tools, such as are shown in figures 12, 13, and 14, have been devised for the purpose of cutting the rings. Two ordinary propagating knives having single blades may be fastened together and made to answer the purpose, although they are less liable to make uniform incisions. Cut a ring of bark from the stock with one of the tools, slit it with a single-bladed knife, and lift from its bed or "matrix," as it is technically called. Discard

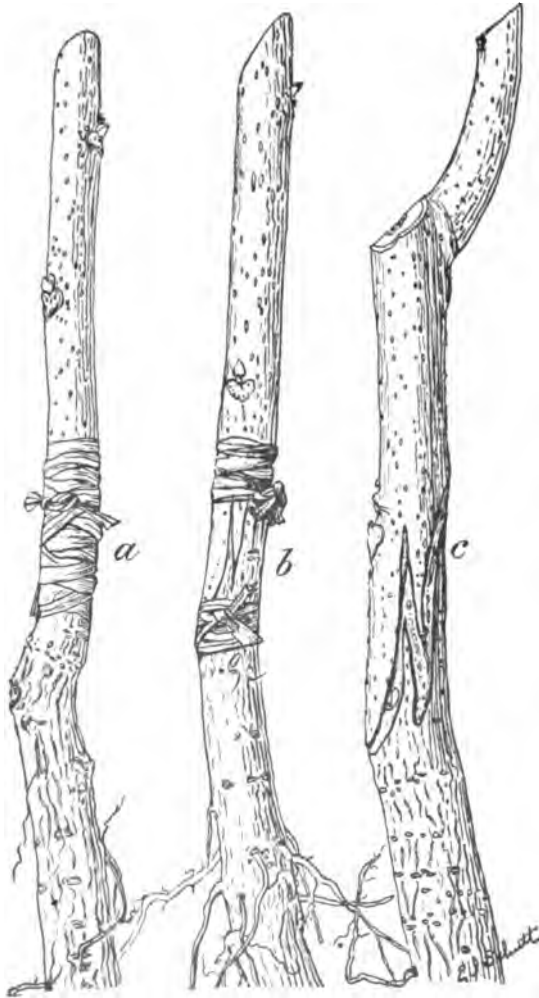


FIG. 11.—Whip grafting. Later steps in the operation: a, Proper method of tying; b, improper method of tying; c, one year's growth following a successful union.

this bark and from the bud stick remove a similar ring, in the center of which is a dormant bud. The bark of the bud stick should be slit on the side opposite the bud. Immediately place this ring in the

¹ The bud stick is a branch, usually about 2 feet in length, cut from a tree of the variety to be propagated.

space left by removing the bark from the stock and wrap at once with waxed cloth, taking care not to cover the bud (fig. 15).

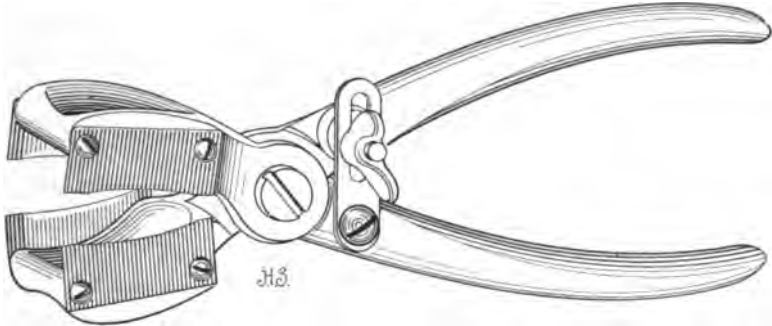


FIG. 12.—A metal tool specially designed for use in annular budding.

BUDDING BY THE PATCH METHOD.

When the annular method is used it is obvious that the stock and scion must be of nearly the same size. If the bud stick is slightly

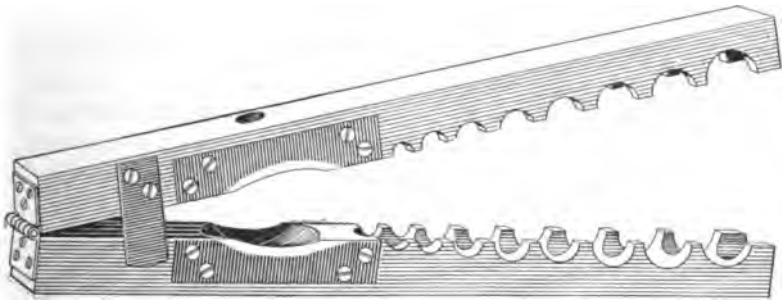


FIG. 13.—A tool with wooden handles and steel blades specially designed for use in annular budding.

larger than the stock a portion of the bark to which the bud is attached may be cut away so that the two ends of the ring just meet around the stock. If the bud stick should be smaller than the stock a strip of bark on the latter may be left in position to complete the ring.

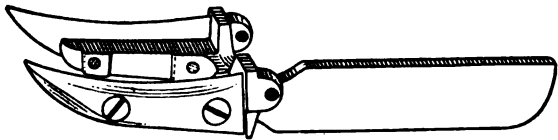


FIG. 14.—Another type of metal tool specially designed for use in annular budding.

In actual practice, rings which extend only partly around the stock are most commonly used. Such process, however, is not true annular budding, because any bark which extends only partly around

the stock is merely a patch. It is to this deviation from the annular method of budding that the term "patch budding" has been applied. A tool specially designed for patch budding is illustrated in figure 16.

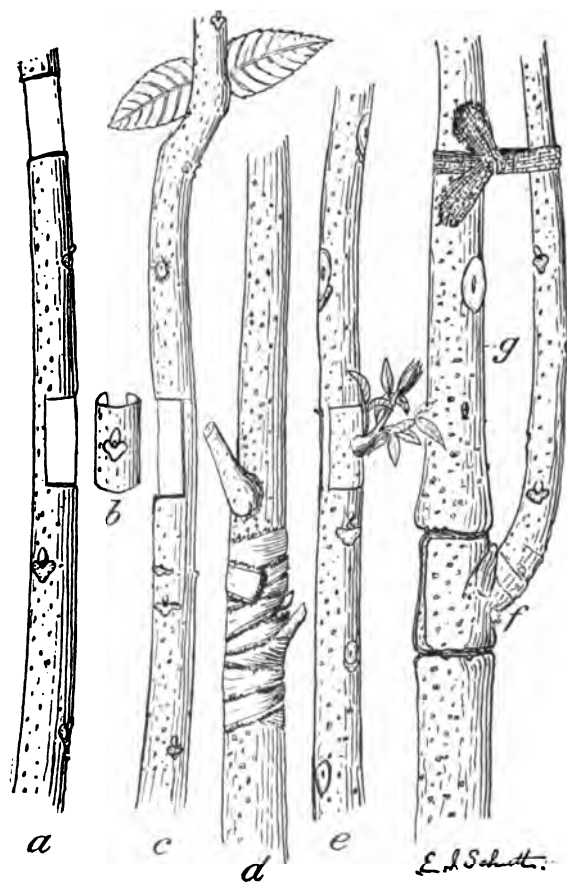


FIG. 15.—Annular budding. *a*, Bud stick from which the bud has been removed; *b*, the bud ready for insertion in the matrix of the stock; *c*, the stock ready to receive the bud; *d*, the bud after being placed in position and carefully wrapped; *e*, growth taking place, the wrapping having been removed; *f*, growth from the bud supported by being tied to the stock (*g*) above the union. Note the scars above the union, where the buds were removed in order to direct the flow of sap to the new bud.

the stock is lifted, and the bark from the bud stick is put in its place. Some varieties of the pecan are more difficult to bud successfully than others; with such varieties the annular method, or a near approach to it, is generally most successful.

It consists of four thin steel blades fastened together in the form of a rectangle, five-eighths of an inch wide by 1 inch long, and is used as a punch.

A very fair degree of success in patch budding by using an ordinary single-bladed budding knife is reported from Texas. A cut is made in the bark of the bud stick about half an inch in width by three times as long, in the center of which is the bud. The piece of bark so outlined is removed from the bud stick and laid over that of the stock. Using this as a pattern, incisions are then made around it in the bark of the stock. The pattern is then removed, the section of bark outlined in

With the average sorts, however, the tendency among the more experienced nurserymen is much inclined to favor the patch method, which may be performed with any of the tools illustrated in figures 12, 13, 14, and 16.

The buds best suited to annular or patch budding are those in the axils of the leaves at the base of the current season's growth. It is well worth the time required to clip the leaves away, close to the buds, 10 days or 2 weeks before the bud is wanted, for by so doing the wound will heal over before the bud is needed; otherwise a serious lessening of the vigor of the bud through evaporation may take place.

CARE OF ANNULAR AND PATCH BUDS.

In annular budding the added ring of bark sometimes unites with the stock promptly, permitting the upward flow of sap to proceed without much interference. When this is the case the top should be carefully pruned back to such a degree as is necessary to direct sufficient sap into the new bud to cause it to swell. This pruning should not be done with too great severity, as an oversupply of sap is liable to accumulate under the bark of the new bud and cause it to decay or, as it is termed, "to drown" the bud. If the tree is young and the growth has been rapid, precaution should be exercised in cutting back the top in order not to expose the tender bark to the heat of the sun. A sufficient amount of foliage should be left as a protection from the hot sun. If the supply of sap be limited, it will be well to cut out all buds in the top of the stock as shown in figure 15. All dormant buds, both above and below the new bud, should be rubbed off as soon as they begin to swell. The wrapping about the new bud must be cut as soon as growth begins. As the union of a bud with a stock made by any method of budding is at first merely the uniting together of bark and not of wood, it is necessarily weak during the first few months. To avoid danger of breaking out at the bud the new tops should be provided with extra support. For this purpose side stakes driven into the ground are sometimes used, but these are expensive and unnecessary. By leaving a stub of the original top 8 or 10 inches long, entirely denuded of foliage (g, fig. 15), the new top may be quickly tied to it, and when no longer needed the dead stub may be cut away close to the union.

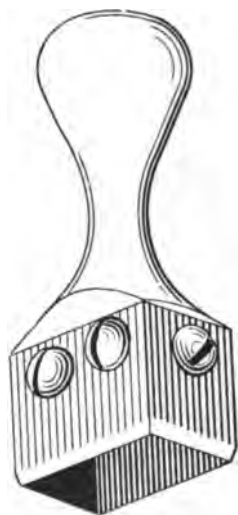


FIG. 16.—A metal tool specially designed for use in patch budding.

BUDDING BY THE CHIP METHOD.

Propagation by chip budding is performed in the early spring or late in the dormant period. Because of being done at this season it is also known as "dormant" budding. With a sharp knife a downward cut is made below the bud on the bud stick to a depth of perhaps one-eighth of an inch. Raising the knife to a point above the

bud a long downward cut is made which meets the lower end of the first cut and the bud is removed with a chip attached, as shown in figure 17. A similar chip is removed from the stock and the desired bud is put in its place. This should be carefully wrapped with such material as will hold the cambium layers of the stock and the bud firmly together on at least one side.

Subsequent treatment similar to that already described for annular and patch budding should be given young trees propagated in this manner.

Trees of the pecan species are difficult to propagate asexually;

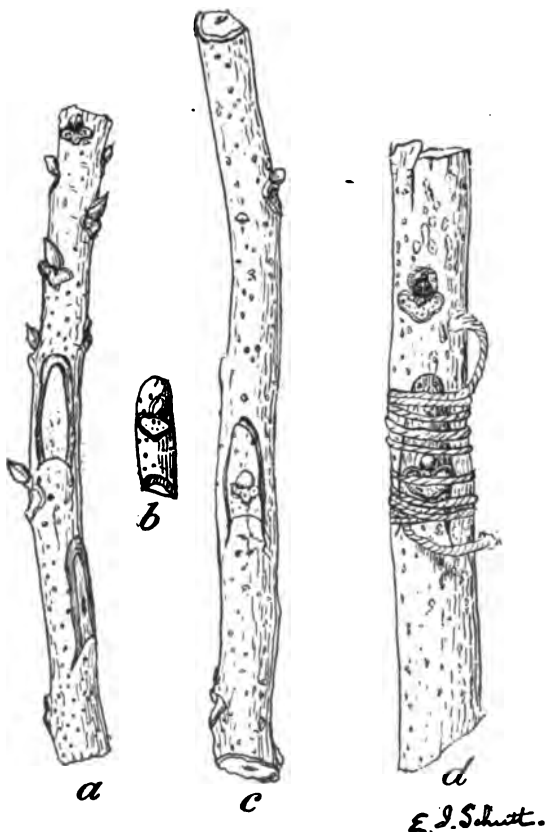


FIG. 17.—Chip or "dormant" budding. *a*, The bud stick; *b*, the bud ready for insertion; *c*, the bud inserted in the matrix of the stock; *d*, the bud securely tied in place.

that is, neither buds nor scions "take" with the readiness of ordinary fruit trees. The inexperienced operator, therefore, must expect a very low percentage of living buds as the result of his first attempts. Skilled propagators, however, are now so successful that under favorable conditions the percentage of failures is no longer a matter of consequence.

No attempt to bud pecans should be made on rainy days or in early mornings following heavy dews. Some nurserymen even go so far

as to select their men for budding the pecan, assigning those who perspire most freely to other duties. Extremely hot days should be avoided, especially if accompanied by drying winds. Moderately cool, cloudy days without wind or rain are the best for pecan budding.

STOCKS FOR GRAFTING AND BUDDING.

LENGTH OF TIME TREES SHOULD REMAIN IN THE NURSERY.

In the Gulf Coast States seed nuts are ordinarily planted during the months of January and February. With conditions favorable for rapid growth, a majority of the young seedlings should be large enough to graft in 12 months and should be ready for transplanting by the end of the second season. If they are to be budded they should reach sufficient size for that operation by the middle of the second season or when at the age of 18 months. Another period of equal length will be required for the trees to attain the desired size for transplanting. It will thus be seen that under exceptionally favorable conditions grafted trees will be ready for planting in the orchard two years from the time of planting the seed as compared with three years for budded trees under ordinary circumstances. In actual practice, however, comparatively few trees attain sufficient size for grafting until the end of the second season; the greater amount of grafting is, therefore, performed on 2-year-old roots. In either case the age of the root is the same, whether grafted or budded, and when established in the orchard the method by which a tree was propagated becomes immaterial.

TOP-WORKING.

The importance of changing the tops of pecans and other nut or fruit trees by the top-working method can hardly be overestimated. By this method seedlings and trees of unsatisfactory varieties may be quickly transformed into bearing trees of more valuable kinds, new varieties may be hastened into bearing, untried sorts may be quickly tested in a new locality, several sorts may be tested on the same tree, and varieties grafted to uncongenial stocks may be given a new trial by being transferred to other trees. Seedling orchards scattered over the entire pecan area are already being transformed in this manner. Wild trees, both in the forest and in the open, are being similarly improved.

STOCKS FOR TOP-WORKING.

For the purpose of top-working, trees of both the pecan and the hickory species are used. Although belonging to the same botanical family as the walnut and the butternut, the pecan is of a different

genus. The relationship is too distant to make the grafting of it upon stocks of either worthy of the attempt. The matter of top-grafting the hickory is discussed under another heading (p. 33).

In general, it is possible to transform the tops of pecan trees of practically any size or age by top-working; but the advisability of attempting so to transform giant trees or such as have begun to deteriorate with age is very doubtful. The operation is of chief value to healthy trees under 30 years of age.

HOW TO TOP-WORK.

The operation of top-working is begun during the dormant season. At that time little danger of killing the trees by severe pruning is incurred. With the exception of a few branches which should be left to utilize the excess of sap while the development of the new top is in progress, the top should be cut back to the point at which the new head is to begin. Commonly the lower three or four limbs are left for this purpose. In working over a large number of trees an elevated platform built at convenient height and attached to a wagon for use during the several stages of the operation will be a great convenience. If the limbs to be cut are large, wind a heavy chain about the branch immediately below the place of cutting, in order to obviate the danger of splitting. A shallow cut on the lower side will further tend to reduce this danger. Trunks more than 6 inches in diameter heal more slowly than those of smaller size; whenever practicable the larger trunks should not be cut. Figure 18 illustrates a tree properly cut back and figure 19 shows one which was cut back too severely. If desirable, the top may be cleft-grafted as soon as cut back, or new growth may be allowed to start, to be budded in midseason by whatever method may be preferred. In small trees three healthy scions or buds centrally located will be enough to insure a symmetrically formed top. As soon as the new growth reaches sufficient size to utilize the entire flow of sap the remaining branches of the original top should be removed. Figure 20 shows a 7-year-old tree which was cut back¹ in February, 1908, budded August 10 of the same season, and the lower branches of which were removed September 1, 1909. The four spurs below the branches indicate the points at which the branches were cut away. These spurs were later pruned closely during the dormant season.

Figure 21 shows a large tree near Morgan City, La., top-worked when about 25 years old and photographed six or seven years later. The points at which the operation was performed are indicated by the right-angular union more or less distinct in each branch. It is a very well-shaped tree. An objection to this method of top-working

¹ Top-worked by Mr. B. W. Stone, Thomasville, Ga.

lies in the fact that the new head of the tree must be formed considerably higher than the old and there is danger that it will be too high. This is especially true with varieties such as the Stuart, Jewett, and others which are inclined to upright growth. If the original top is already high, it is generally best to cut back and graft the lower branches a year before cutting away the central part of the top. Enough of the top may be cut back at the same time to force a liberal supply of sap into the graft. The sap can not be directed to the lower limbs in this manner if the higher limbs are grafted first, for in that case pruning will be fairly certain permanently to disturb the symmetry of the new top.



FIG. 18.—Seedling tree cut back during the dormant season to induce new growth for top budding.

TOP-WORKING HICKORY WITH PECAN.

Because of their close relationship the scions and buds of the pecan readily unite with stocks of the hickories. The advantages sought in such operations are the quick introduction of the pecan to localities to which it is not common but where hickories abound, the utilization of trees of inferior species, and the possibility of discovering a stock for the pecan which will have certain advantages over those ordinarily used. A number of species are known to have been tried; in southern Louisiana several trees of the water hickory (*Hicoria aquatica*) in standing water produced a healthy, strong pecan top, but later died outright, while others of the same species

not top-worked remained alive under the same conditions; another of these trees taken up and transplanted to drier land made good growth and according to latest reports was bearing satisfactorily.



FIG. 19.—Seedling tree cut back to a stump 15 inches in diameter, for top-working. With large trees the sprouts on one side only should be budded. As large a portion of the stump as possible should be hewn away in order to allow the wound to heal.

In Florida, where the mockernut (*Hicoria alba*) is common, the pecan has been found to unite readily with it and to make a rapid growth until the diameter of the pecan becomes equal to that of the

hickory, after which it grows much more slowly. Other hickories have been tried; while the early growth is generally reported to be

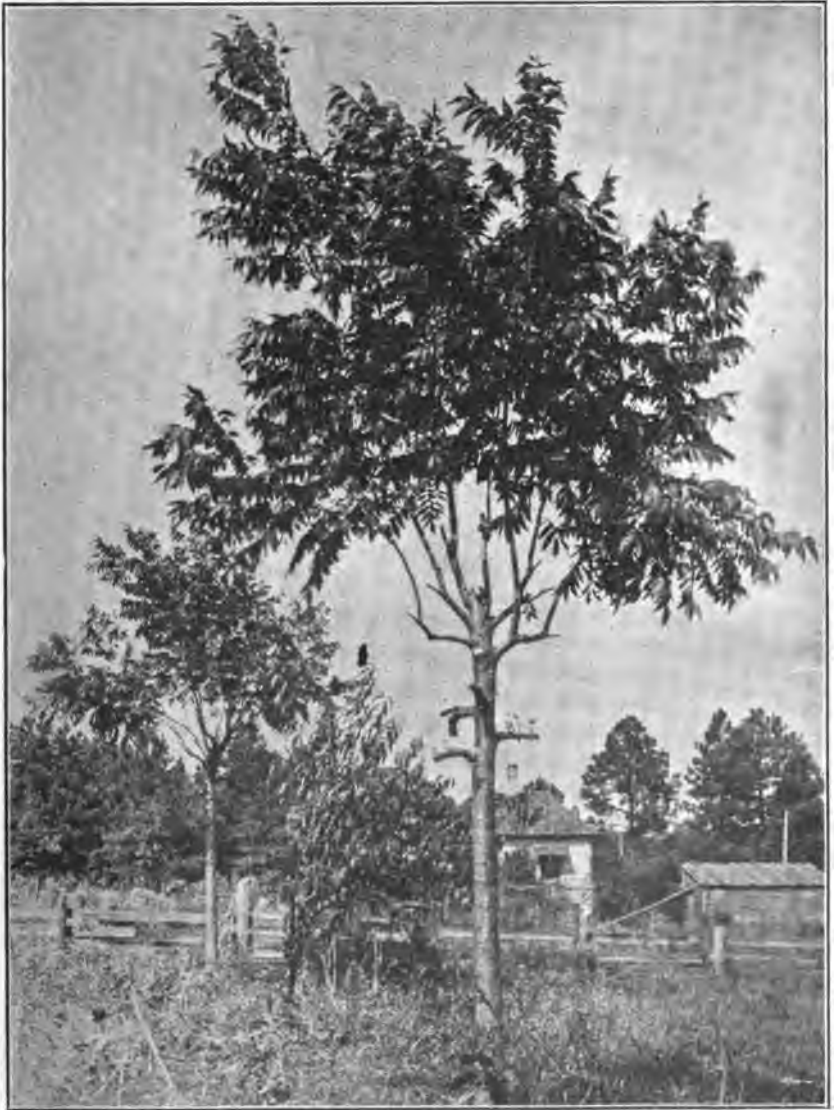


FIG. 20.—A 7-year-old pecan tree top-worked with Stuart scions. The seedling top was cut back in February, the buds were inserted August 10, and the lower branches removed September 1 of the next year. Note how the head of the tree has been elevated.

strong and rapid, very few have thus far proved satisfactorily fruitful.

As hickory trees top-worked with pecan usually stand in out-of-the-way places, not uncommonly in wood lots, it is doubtful whether



FIG. 21.—Pecan tree in Morgan City, La., top-worked when about 25 years old and photographed 6 or 7 years later. A very well-shaped tree, although headed rather high.

the reason for unfruitfulness is due to the influence of the hickory species or to the lack of cultivation.

Department investigators have generally observed a conspicuous difference in the rapidity of growth between the hickory stock and the pecan scion. As a usual thing the pecan is the more rapid grower, as is illustrated by figure 22, which undoubtedly affords the earliest

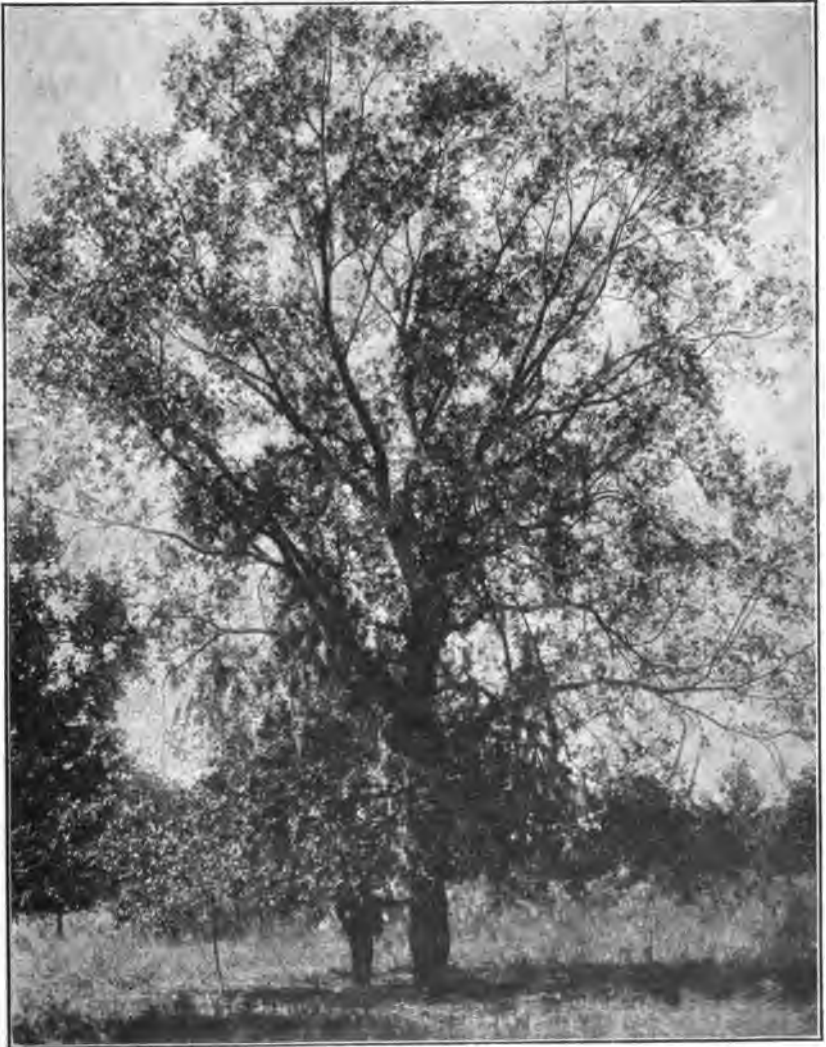


FIG. 22.—Pecan tree grown from a graft on a hickory stock inserted about 1880. Note the enlargement of the trunk 2 feet above the ground, the point at which the union was made.

instance on record of a pecan tree¹ grafted to a hickory stock. The operation was performed 1 foot from the ground about the year 1880. The tree is now 40 or 50 feet tall and has a spread of about the same

¹ Near Gainesville, Fla. Photographed in October, 1910.

distance. The trunk measured 5 feet 9½ inches in circumference below the graft, 6 feet 11 inches at the point of union, and 6 feet at breast height. It was, therefore, 1 foot 1½ inches greater in circumference at the point of union and 2½ inches greater 4 feet from the ground than the hickory trunk at the place of its greatest circumference.

Nothing is known of the source of the pecan scion, but it is not improbable that it was cut from an ordinary seedling. The bearing record of this tree is unknown, but as it stands in rather poor soil and bore no nuts during the year observed (1910), it has probably never fruited to any considerable extent.

PLANTING.

Orchard trees are ordinarily transplanted from the nursery to their permanent location during January or February. The soil should first be put in good condition by thorough cultivation and, if necessary, steps should be taken to insure proper drainage.

The usual distance for planting differs in localities. In the deep alluvial lands of Louisiana and the Mississippi Valley, where it is expected that the trees will attain greater size than when grown in the lighter soils of the more eastern States, pecans are now being set at distances varying from 50 to 75 feet. Some planters, having in mind the idea that 100 feet will be the most suitable distance when the trees reach maturity, are planting at 50 feet, with the intention of removing the alternate trees as soon as crowding begins, leaving them eventually 100 feet each way.

In Georgia, a distance of 46 feet and 8 inches each way (20 trees to the acre) was adopted for some years, but as the orchards so set approach maturity it is becoming evident that considerably greater space would have been better. These planters now agree that 60 feet apart (12 trees to the acre) is not too great a distance.

TREES FOR PLANTING.

As has been explained, nursery-grown trees are mostly planted at the age of 3 years. While sometimes sold as though graded according to age, they are actually graded according to size. If sold under the age grade the largest trees are naturally the "oldest." For this reason it is much more satisfactory to buy according to size, although in that case there is danger of slow-growing stock being worked into the lot. Within certain limits a nursery-grown pecan tree which has reached a given size in a given length of time is much to be preferred to one which has been twice as long in attaining the same size. It is natural to expect that the rapidity or slowness of growth displayed in the nursery will be relatively the same throughout the life of the

tree. For this reason the healthy, quick-growing trees in the nursery are much preferable to those which grow slowly. Figure 23 shows five trees, selected to show one of each of the grades adopted by nurserymen. Beginning at the right the grades of 1 to 2 feet, 2 to 3 feet, 3 to 4 feet, 4 to 5 feet, and 5 to 7 feet are represented. These measurements are of the top only; the length of the taproot is not taken into consideration.

The taproot, which it was once thought necessary to protect in transplanting, is now cut off about 2 feet below the surface. In a nursery¹ visited during the fall of 1910, a tool specially designed for the purpose was being used in cutting off the taproot.

Purchasers of nursery stock should insist that the trees be allowed to remain in the nursery in the fall until all growth has ceased and the foliage has fallen normally. The early demand for trees has recently impelled nurserymen to dig a great portion of their trees while still in full leaf. At that



FIG. 23.—Nursery-grown pecan trees, showing the standard grades. Right to left: 1 to 2 feet, 2 to 3 feet, 3 to 4 feet, 4 to 5 feet, 5 to 7 feet. The seed from which these trees were grown was planted in January, the seedlings were whipgrafted during the month of February of the second year following, and the trees were dug in the succeeding November. The board upon which the trees are standing indicates the point at which the taproots were cut.

season neither the top nor the root system is in a condition to be disturbed. The cutting away of foliage, branches, and roots while the sap is still in circulation results in a heavy shock which is inju-

¹ The Monticello Nurseries, Monticello, Fla. Digitized by Google

rious and wholly unnecessary. It is therefore highly important that every buyer of southern varieties of pecan trees grown in the South should insist that the trees be not dug until the leaves have dropped naturally, which is usually about the middle of November. With northern varieties the situation may be different, as the wood of these varieties matures very much earlier. However, with southern varieties grown in the South, it would be better for the trees not to be dug from the nursery rows before the last of November in any season.

SETTING THE TREES.

Extreme precaution should be taken to prevent the roots from becoming dry. They should be kept carefully covered from the time they are dug until finally set. A large hole, fully twice or three times the size actually required to receive the roots, should be dug. A quantity of well-rotted compost or nitrogenous fertilizer placed in the bottom of the hole, entirely covered with earth before setting the tree, will furnish plant food during subsequent seasons and tend to induce a deep root system. Immediate contact of the roots with compost or fertilizer of any kind must be avoided. All broken parts of the roots and all lateral branches of nursery-grown trees should be pruned away. Soaking the roots in a bucket of water for an hour or two or even over night gives the trees a very great advantage. The trees should be placed in the hole at about the same depth as they grew in the nursery. Spread out the roots carefully with the hands and pack firmly with moist surface soil thoroughly pulverized. If the soil is dry, it should be drenched with water before the hole is entirely filled.

CULTIVATION.

Satisfactory tree growth and bearing qualities can be expected only in return for careful attention to cultivation and orchard management. In addition to being unsatisfactory in bearing, neglected trees are very apt to become far more subject to attacks of fungous diseases and insect pests.

A common practice in the Southern States is that of renting the land between the rows to tenants, reserving a narrow strip on either side of the row to be cultivated and fertilized by the owner. As the trees approach the bearing age this strip is widened until all the land is included, after which cover crops only are grown between the rows. A good many soils in which pecan trees are now being planted are of such low fertility that they should be replenished with plant food rather than be further impoverished with intercrops. Of the crops

being grown between the rows, cotton and corn are the most common, although truck crops are not infrequent. Legumes, such as cowpeas, velvet beans,¹ lespedeza, and bur clover, are most commonly used for soiling purposes.

BEARING AGE.

Owing to the infancy of the industry, very little data as to the ages at which pecan orchards come into bearing are yet obtainable. This lack of information is partly due to the fact already made clear that with few exceptions practically all orchards planted prior to 1903 were of seedling trees and therefore of very uncertain bearing habits and partly for the reason that a great majority of the grafted and budded trees were of varieties which later proved to be shy bearers. Of the trees which have been planted since 1903 a great many are bearing to some extent. It is not unusual for trees of some varieties when grown under favorable conditions to mature a few nuts by the end of the second or third season after transplanting from the nursery to the permanent orchard location. A few nuts, however, can not be considered a crop. It is not improbable that such early bearing is detrimental to the vitality of the trees. In the belief that trees should not be allowed to bear until they have attained size, root hold, and constitutional vigor proportionate to that of maturity, some of the leading orchardists are now managing their orchards so as to prevent commercial production of nuts until the trees are 8 to 10 years of age.

NUT HANDLING.

HARVESTING.

In the latitude of north Florida the period of ripening and harvesting begins with certain varieties in some years as early as September 5 and with others extends until late into December.

The hulls open partly or entirely and the nuts fall to the ground, or they are whipped from the trees with poles of bamboo or other light material, after which they are gathered up and taken to shelter. No machinery has yet been devised for separating the nuts from the hulls; consequently this work is done by hand. In sections where the pecan is native, professional thrashers beat the nuts from the trees for a stipulated fee or for a portion of the crop, according to agreement.

In order to dry the nuts thoroughly as soon as separated from the hulls they are spread to a depth of not more than 3 inches upon

¹ The velvet bean is a remarkably vigorous grower and special precaution should be taken to prevent it from running over the young pecan trees, causing them to break down with the weight of the vines.

racks with perforated bottoms, so placed that the air will have free circulation above and below. With frequent stirrings the process of drying may be hastened so that in favorable weather the nuts may be ready for market in from 10 days to 2 weeks. A very appreciable loss in weight by evaporation will continue for some weeks following the ordinary period of drying.

MARKETING.

Comparatively few nuts of the improved varieties reach the general markets. They are largely sold to nurserymen for use as samples, occasionally to seedsmen, and to tourists, fancy confectioners, private consumers, and recently to a rapidly increasing class of in-



FIG. 24.—Wagons loaded with native pecans in Texas awaiting the arrival of buyers.

dividuals engaged in promoting land sales of orchard property. The nuts are put up in any shape or style of package that may suggest itself, and shipments are sent by mail or express directly from the producer to the consumer. The pound is the unit of measure by which such sales are made. No standard package has been adopted by the trade and so far as known no grower has his own trade-mark, as is the case with leading growers of citrus and other fruits.

When thoroughly dried the wild nuts are placed in burlap sacks holding 100 to 150 pounds and hauled to the local markets, where they are inspected and bid upon from the wagons drawn up in the streets much the same as grain dealers buy wheat in the Northern States. Figure 24 shows three wagon loads of pecans in the central

part of a Texas town¹ awaiting the arrival of buyers. From the local buyers they are sent in car lots to the larger markets, principally in San Antonio, New Orleans, Kansas City, St. Louis, Chicago, Cincinnati, Buffalo, and New York, whence they are distributed to smaller cities.

CLEANING, POLISHING, AND TINTING.

As the harvesting season extends over a period of two to three months, a large proportion of the nuts become considerably discolored and their surfaces more or less covered with particles of soil. To remedy this condition the nuts are rotated in cylinders of several hundred pounds capacity; the rubbing together in the cylinders removes the dirt and cleans and polishes the surfaces of the nuts, and they are then known as "polished" pecans. During the polishing



FIG. 25.—A pecan crackery.

process the natural rich appearance of the nuts is lost. Another common process by which wild pecans are prepared for market consists in the immersion of the nuts in a reddish dyeing solution, after which they are dried and polished by the method just described. The latter operation is known as "tinting" or "staining." Nuts thus treated may be readily detected by their bright, unnatural color, which is easily removable with a moistened finger.

CRACKING.

The invention of machinery for the cracking of pecans without breaking the kernels is undoubtedly more largely responsible for the marked increase in the demand for pecan products during recent

years than any other single factor. Some crackeries in the cities of San Antonio, St. Louis, Chicago, and New York are supplied with machines having a daily capacity of 500 to 800 pounds each. Figure 25 shows a crackery¹ in San Antonio in which 30 to 40 of these machines are installed, having a total maximum capacity of 20,000 pounds daily. After the nuts are cracked the kernels are separated from the shells by hand, generally within the same crackery. Of the wild product, approximately 60 per cent of the total weight of the nut is shell, or about 40 per cent kernel. Of those cracked, depending largely upon the character of the nut itself, the perfection of the machine, and the skill of the operators, from 75 to 80 per cent by weight is separated from the shell in unbroken half kernels. These kernels are placed in boxes, barrels, or other packages and sent to the retail markets, where the present prevailing price ranges from 60 to 85 cents a pound.

SIZING.

Public fancy is most readily attracted by mere bigness, and, as most of the cracking machines do not adapt themselves to varying sizes without special adjustment, the need of uniformity in size becomes apparent. To meet this exigency various sizing devices have been perfected. The type of device used by at least one of the large cracking companies consists of a hollow cylinder 24 feet long and 2 feet 3 inches in diameter, one end being slightly elevated. This cylinder is made up of three sections of equal length composed of iron rods placed equal distances apart, the distance varying in each section. The pecans are fed into the upper end of the cylinder, which has the smallest spaces between the rods. The cylinder is rotated slowly, the smallest nuts falling between the rods, while those of the larger sizes are carried forward. In experiments made by this Department with pecans of named varieties it has been found that a diameter difference of one-sixteenth of an inch is sufficient to constitute a difference between sizes.

VARIETIES.

ORIGIN OF VARIETIES.

Single trees possessing such superior merit over those of the general average in the matter of size, quality of nut, thinness of shell, productiveness, and other characteristics as to justify their propagation by grafting or budding have been given individual names and established as varieties. Varietal names apply to the original

¹ Photographed Nov. 7, 1910.

tree and to all trees grafted or budded from it, but not to those grown from its seed. Ordinarily these original trees are chance seedlings; exceedingly few varieties have thus far resulted from systematic breeding. Since attention has been called to the value of such individual trees, several hundred have been discovered, and more than 100 have been propagated as new varieties. Of these new varieties, however, comparatively few have proved to be of sufficient value to warrant their general sale to the public. The development of varieties superior in one or more respects to those already established and of varieties especially adapted to given localities is greatly to be commended, but unless a nut is plainly of special merit the attempt to add it to the present list of varieties should be discouraged, as mediocre sorts are already very numerous. It takes time to prove the value of a good variety in any locality; many good sorts are already available from which to select, making it not worth while to pay fancy prices for propagating wood or nursery-grown trees of any new sort, no matter how much may be said in its favor. In this bulletin the discussion of individual varieties is limited to such sorts as are best known or have been thought by some to be more or less promising.

SELECTION OF VARIETIES.

No factor in pecan culture is of greater importance than the selection of varieties for planting. Upon it alone may depend the success of the orchard. The following general suggestions are intended to be of service to the prospective planter.

(1) Ordinarily, varieties do not readily adapt themselves to soil and climatic conditions differing widely from those common to their place of origin.¹ Unless varieties have already demonstrated their adaptability to the soil and climatic conditions in a given locality they should be tested experimentally before being planted commercially.

(2) As far as practicable, varieties which have proved to be at least fairly resistant to fungous diseases and insect pests should be selected.²

¹ Evidence of this statement lies in the fact that when taken to the more humid climate of the Eastern States a number of the leading varieties (including San Saba, Sovereign, Kincaid, and Halbert) which originated in the semiarid portions of Texas have developed a marked degree of susceptibility to the fungous disease known as pecan scab. Furthermore, experience thus far has not been such as to encourage the planting of eastern varieties in the semiarid portions of the Southwestern States or southern varieties in the North other than to an experimental extent. Northern varieties have not yet been tried in the South to any great extent.

² It is highly improbable that any variety will ever be discovered which will be altogether immune under all conditions to fungous diseases or insect pests; but some varieties are known to be less subject to certain diseases than others and considerable evidence at hand indicates that some are less affected by certain insect pests than others.

(3) The market for which the nuts are intended should be borne in mind at the time of selecting varieties for planting.¹

PAPERSHELL PECANS.

With reference to the pecan the term "papershell" has been extended in its application until it is now practically without significance. Originally applied to those types of pecans having such thin shells that one nut could easily be cracked when two were placed in the hand and crushed together with both hands, the term during recent years has been made to include all cultivated varieties, many of which have fully as hard shells as the average wild nuts. Properly speaking, the term "papershell" never referred to a particular variety; its correct application has been only with reference to the group of varieties having very thin shells.

DESCRIPTION OF VARIETIES.

No attempt is made in this publication to discuss the merits of all varieties known to the trade; only such as are well known or at some time have been thought to give promise as future varieties are included.

Alley.

From Jackson County, Miss. Widely disseminated since being introduced in 1896; size medium; shell thin; kernel plump; flavor good; a medium to heavy bearer and symmetrical, vigorous grower, somewhat subject to scab under certain conditions. Should be planted conservatively.

Appomattox.

Recently introduced from Dinwiddie County, Va. Parent tree not in normal condition, owing to stable built under tree. Size medium; shell of average thickness; flavor said to be good; believed to be promising for northern planting.

Atlanta.

From southwestern Georgia. Very much subject to scab.

Aurora.

From Mobile County, Ala. Not yet propagated to a great extent; size large; shell somewhat thick; partitions rather corky; kernel fairly plump; flavor good to very good. Probably adapted to markets catering to large nuts.

Beman.

From Hancock County, Ga. Propagated to a limited extent only. Size below medium; shell rather hard; kernel plump, bright colored, rich, and of excellent flavor. Very productive. Promising for north Georgia and vicinity.

Beveridge.

From Orange County, Fla. Large, but too shy in bearing and too much subject to scab to be of value.

¹ For the market in which pecans are sold without being cracked, nuts of large size have a distinct advantage at the present time; in all probability this preference for size will continue. The varieties of medium size have certain cultural advantages over the larger types in that they are less often shy or irregular in bearing and are generally better fillers.

Bolton.

From Jefferson County, Fla. Size above medium; shell moderately thin; kernel not always plump; flavor fairly good. Bearing record not proved. Needs further testing.

Bradley.

From Baker County, Fla. Size below medium; shell of average thickness, hard; kernel plump; flavor very good. Very productive. Especially promising for Florida and south Georgia.

Burkett.

From Callahan County, Tex. Size large; shell thin; kernel plump; flavor excellent. Said to be productive. Should be especially adapted to planting in west Texas.

Centennial.

From St. James Parish, La. The first variety known to be propagated. Widely disseminated but very tardy in bearing. No longer planted to any considerable extent.

Claremont.

From Concordia Parish, La. Not yet extensively propagated. Size medium; shell somewhat thick; kernel plump; quality rich; flavor excellent; very productive. Considered very promising, especially for planting in northern range of the area adapted to southern varieties.

Colorado.

From San Saba County, Tex. Little propagated as yet. Size large; shell somewhat thick; kernel plump; quality rich; flavor excellent. A seedling of San Saba. Probably especially adapted to planting in western Texas.

Curtis.

From Alachua County, Fla. Size below medium; shell thin; kernel plump; quality rich; flavor excellent. Very productive. Widely disseminated. Popular in Florida.

Daisy.

From Comal County, Tex. Widely disseminated though not extensively planted. Size medium; shell moderately thin; kernel plump; quality rich; flavor very good. Tree vigorous; said to be productive; probably best adapted to western Texas.

Delmas.

From Jackson County, Miss. Widely disseminated. Size large to very large; shell moderately thin; kernel plump; quality good to very good; flavor excellent. Tree vigorous; productive. Very much subject to scab under certain conditions.

Dewey.

From Jefferson County, Fla. Size medium; shell thin; kernel plump; quality rich; flavor excellent. Tree of rather awkward habit and thus far irregular in bearing.

Frotscher.

From Iberia Parish, La. Widely disseminated. Size large; shell very thin; kernel moderately plump, often dark colored; quality fair; flavor medium. Popular in southwestern Georgia and parts of Louisiana.

Georgia.

From Mitchell County, Ga. Size above medium; shell thick, rather hard; kernel plump; quality good; flavor pleasant. Very prolific but extremely subject to scab in most places where tried. Should be avoided for the present.

Greenriver.

From Henderson County, Ky. Propagation recently begun. Size somewhat below medium; shell of average thickness; kernel plump; quality rich; flavor excellent. A promising variety, especially for northern planting.

Hadley.

From McDuffie County, Ga. Propagated to some extent in Grady County. One of the very large varieties, not yet well known.

Halbert.

From Coleman County, Tex. Widely disseminated, mainly by scions used in top-working. Size small; shell very thin; kernel unusually plump; quality rich; flavor excellent. Very prolific. Especially adapted to planting in western Texas and places of similar climatic conditions.

Hall.

From Jackson County, Miss. Not widely disseminated. Size very large; shell thin; kernel usually plump, frequently defective; quality dry; flavor medium. Very prolific.

Havens.

From Jackson County, Miss. Not widely disseminated. Size medium to large; shell very thin; kernel plump; quality good; flavor sweet though sometimes slightly astringent. One of the most promising new varieties, especially for Gulf coast planting.

Hodge.

From Clark County, Ill. Not propagated to any great extent. Size medium; shell rather thick; kernel somewhat shriveled; quality fair; flavor pleasant.

Hollis.

From San Saba County, Tex. Not widely disseminated outside of central and western Texas. Trees of this variety were at one time sold to some extent under the name *Post's Select*. Size medium to large; shell thick, soft; kernel plump; quality good to very good; flavor sweet.

Indiana.

From Knox County, Ind. Not yet widely disseminated. Considered highly promising for planting in the northern range. Size medium; shell of average thickness; quality said to be good.

Jacocks.

From Orange County, Fla. Size large and shell thin; awkward grower; irregular bearer and much subject to pecan scab.

James.

From Madison Parish, La. Not widely disseminated. Size medium; shell thin; quality rich; flavor sweet. Very prolific. Thought to be highly promising for the northern portion of the range of southern varieties.

Jewett.

From Jackson County, Miss. One of the earliest varieties disseminated. Fairly prolific but a very poor filler. Tree trunks of this variety are often subject to a peculiar bark disease. No longer planted by those familiar with it.

Just.

From Tarrant County, Tex. Recently introduced. Size small; shell very thin; kernel slightly shrunken; quality rich; flavor sweet. Said to be very prolific. Evidently well worthy of trial in central and western Texas.

Kennedy.

From Alachua County, Fla. Not widely disseminated. Size medium to large; shell moderately thin; quality very good; flavor sweet. Very productive in some years. Inclined to be irregular. Thought to be especially adapted to central and northern Florida.

Kincaid.

From San Saba County, Tex. Well disseminated in central and western Texas. Size large; shell of medium thickness; kernel plump; quality very good; flavor sweet. Very prolific. Especially recommended for central and western Texas. Very much subject to scab in the Atlantic States.

Lewis.

From Jackson County, Miss. Recently introduced. Size large; shell of medium thickness; kernel plump; quality rich; flavor pleasing. Said to be productive. Believed by introducer to be very promising, especially for Gulf coast planting.

Magnum.

From Mitchell County, Ga. Very much subject to scab. Little planted at present time.

Major.

From Henderson County, Ky. Recently introduced. Not yet widely disseminated. Size slightly below medium; shell thin; kernel unusually plump; quality rich; flavor excellent. Considered especially promising for planting in northern range.

Mantura.

From Surry County, Va. Size medium to large; shell thin; kernel not always plump at tip, somewhat shrunken; quality good; flavor good. Said to be productive. Believed to be especially promising for planting in the northern range.

Melançon.

From St. James Parish, La. Size medium to large; shell somewhat thick; kernel fairly plump; quality medium. This variety has been considerably confused since its introduction. At one time trees of Melançon and Van Deman were sold under the common name of *Paragon*, and it is highly probable that the variety disseminated from Ocean Springs, Miss., as *Capital* is true Melançon. The nuts of *Capital* appear to be identical with those of Melançon, and the scions with which *Capital* was first propagated were obtained from a grafted tree of about the same age as other grafted trees which are known to have been propagated with scions obtained from the same parish.

Mobile.

From Mobile County, Ala. Well disseminated, especially in southwestern Georgia. Size medium to large; shell moderately thin; kernel usually plump, frequently very defective; quality fair; flavor fair. Very productive, but thus far generally objectionable after second or third crop because of great percentage of defective kernels.

Moneymaker.

From Madison Parish, La. Widely disseminated. Size medium; kernel fairly plump; quality fair; flavor sweet. Very prolific. Especially suited to planting in northern range of the area adapted to southern varieties.

Moore. SYNONYMS: *Long Moore*, *Moore No. 1*, *Moore No. 2*.

From Jefferson County, Fla. Size below medium; shell of average thickness; quality fair; flavor fair. Unusually productive and one of the earliest to mature. Well suited to northern Florida.

Nelson.

From Hancock County, Miss. Size very large; shell thick; kernel generally plump, though often very defective; quality medium; flavor good. Tree unusually vigorous; very productive.

Owens.

From Coahoma County, Miss. Just being introduced. Size large; shell thin; kernel fairly plump; quality medium; flavor good. Parent tree said to be very productive. Evidently promising for planting in the northern range of the area adapted to southern varieties.

Pabst.

From Jackson County, Miss. Widely disseminated. Size large; shell somewhat thick; kernel usually plump; quality good; flavor sweet. Generally, productive, though by some thought not to be an early bearer.

Post. *SYNONYM: Post's Select.*

From San Saba County, Tex. Not widely disseminated. Size medium; shell thick; kernel somewhat shrunken; quality good; flavor delicate. Much confused with Hollis.

President.

From Duval County, Fla. Well disseminated in northern Florida. Size medium; shell of medium thickness; kernel plump; quality good; flavor pleasant. Vigorous and productive. Considered as especially promising for central and northern Florida.

Randall.

From Alachua County, Fla. Not widely disseminated. Size large; shell rather thick; kernel plump; quality rich; flavor sweet. Prolific, though irregular in bearing. Evidently well suited to central and northern Florida.

Reuss.

From Ascension Parish, La. Not yet disseminated. Size slightly below medium; shell thin; kernel plump; quality good to very good. Evidently promising, especially for northern range of area adapted to southern varieties.

Robinson.

From Orange County, Fla. Not widely disseminated. Size large; shell rather thick; kernel fairly plump; quality good; flavor pleasant. Very productive. Evidently promising for planting in the southern limits of the area adapted to pecans.

Robson.

From Jackson County, Miss. More or less widely disseminated, though not well known. Size medium; shell thin; kernel somewhat shrunken; quality good; flavor pleasant. From same parentage as Russell, resembling that variety in many respects.

Rome. *SYNONYMS: Columbian, Twentieth Century, Pride of the Coast, etc.*

From St. James Parish, La. Widely disseminated and very well known. Size large to very large; shell thick; kernel usually somewhat shrunken, often very defective; quality medium; flavor fair. Very irregular in bearing habits. No longer recommended for planting.

Russell.

From Jackson County, Miss. Widely disseminated. Size medium; shell very thin; kernel somewhat shrunken; quality good; flavor sweet. Prolific; said to be sensitive to cold weather.

San Saba.

From San Saba County, Tex. Very well known. Size small; shell unusually thin; kernel very plump; quality very rich; flavor excellent. Highly productive. Especially adapted to central and western Texas. Not suited to eastern planting.

Schley.

From Jackson County, Miss. One of the best known and most widely disseminated varieties. Size medium to large, although often variable, even on same tree; shell very thin; kernel plump; quality very rich; flavor excellent. Moderately productive, but a regular, annual bearer. Although sometimes quite subject to scab, it is one of the most popular varieties at the present time.

Seminole.

From Jefferson County, Fla. Not well known. Size medium; shell thin; kernel plump; quality rich; flavor sweet.

Senator.

From Mitchell County, Ga. Not well known. Small; hard shelled; prolific. No longer thought to be promising.

Sovereign. SYNONYM: *Texas Prolific.*

From San Saba County, Tex. Very well known. Size large; shell of medium thickness; kernel plump; quality rich; flavor sweet. Unusually prolific. Especially well adapted to planting in central and western Texas. Not adapted to the Eastern States.

Stuart.

From Jackson County, Miss. More extensively planted than any other variety. Size medium to large; shell of average thickness; kernel plump, usually breaks into crumbs while being extracted; quality good; flavor sweet. Moderately productive. Has succeeded in nearly all parts of the range adapted to southern varieties east of central Texas.

Success.

From Jackson County, Miss. Of comparatively recent introduction. Size large to very large; shell moderately thin; kernel usually very plump; quality rich; flavor very good. Generally reported to be highly prolific. Very promising.

Superb.

From Jackson County, Miss. Not yet disseminated to any great extent. Size medium to large; kernel fairly plump, often defective; quality fair. Judging from specimens examined, this is not a promising variety.

Taylor.

From Harrison County, Miss. Known for some time, but not widely disseminated. Size medium to large; kernel plump; quality very good; flavor sweet. Evidently well adapted to Gulf-coast planting.

Teche.

Thought to be from Iberia Parish, La. Introduced by confusion with Frot-scher. Size medium to small; shell of average thickness; kernel fairly plump; quality medium to poor; lacking in flavor. Unusually productive and generally hardy over the entire range of southern varieties from Louisiana eastward.

Van Deman.

From St. James Parish, La. One of the most widely disseminated of all varieties. Size large to very large; shell of medium thickness; kernel plump; quality rich; flavor sweet. Very popular until recently, when it developed a susceptibility to scab serious in some sections. In the young orchards of the Eastern States this variety has not yet proved to be prolific.

Warrick.

From Warrick County, Ind. Not yet generally disseminated. Size slightly below medium; shell moderately thin; kernel plump; quality rich; flavor excellent. Parent tree reported to be prolific. Evidently a very promising variety for planting in the northern range.

Waukeenanah. SYNONYMS: *Round Moore*, *Moore No. 1*, *Moore No. 2*.

From Jefferson County, Fla. Quite generally disseminated in northern Florida. Size small; shell of average thickness; kernel generally shrunken; quality below medium; flavor poor. Very prolific. One of the earliest to mature. Especially adapted to central and northern Florida.

Wolford.

From Collin County, Tex. Not widely disseminated. Size medium or slightly below; shell very thin; kernel plump; quality rich; flavor very good. Evidently well worthy of planting in central and western Texas.

Young.

From St. Martin Parish, La. Widely disseminated, but not extensively planted. Size large; shell very thin; kernel somewhat shrunken; quality good; flavor sweet. Possibly parent to Russell, which it resembles closely.

Zink. SYNONYM: *Big Z*.

From Jackson County, Miss. Recently introduced. Much like Frotscher in nut characteristics. Size large; kernel often shrunken; quality good. Though of attractive appearance, because of its deficiency in plumpness of kernel it should be held as a test variety.

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[Synonyms are distinguished from the correct varietal names by the use of *italic type*.]

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STUDIES OF FUNGOUS PARASITES BELONGING TO THE GENUS GLOMERELLA.

BY

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LETTER OF TRANSMITTAL

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., April 15, 1912.

SIR: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 252 of the series of this Bureau the accompanying manuscript entitled "Studies of Fungous Parasites Belonging to the Genus *Glomerella*," by Dr. C. L. Shear, Pathologist in Charge of Grape and Small-Fruit Diseases, and Mrs. Anna K. Wood, formerly Scientific Assistant in the Office of Fruit-Disease Investigations. This paper has been submitted by Mr. M. B. Waite, Pathologist in Charge of the Office of Fruit-Disease Investigations.

This bulletin gives the results of studies of a group of fungous parasites of great economic importance. Few fruits are free from the attacks of this fungus. The life histories and relationships as well as the physiological and pathological characteristics of the organism from 36 different host plants are herein recorded, in many cases for the first time. It has been found that what had heretofore been regarded as distinct species of fungi restricted to certain host plants are in reality merely races or strains of one species which is capable of infecting various hosts.

These facts have a very direct and important bearing upon the practical problems of the prevention and control of the widespread and serious diseases caused by these parasites and also upon the broader general biological questions connected with the evolution of plant parasites.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

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STUDIES OF FUNGOUS PARASITES BELONGING TO THE GENUS GLOMERELLA.

INTRODUCTION.

The name *Glomerella* was first applied by Von Schrenk and Spaulding (70)¹ to the ascogenous form of the fungus producing the bitter-rot of the apple and the ripe-rot of the grape, usually referred to in its conidial condition as *Gloeosporium* or *Colletotrichum*. The same fungus, or fungi belonging to the same genus, attacks a great variety of other plants and produces diseases which are sometimes called "anthracnose," of which the anthracnose of the bean is a familiar example. In current usage, the term "anthracnose" is applied to diseases caused by fungi belonging to a few other genera besides *Glomerella*. It would be better if the name "anthracnose" were restricted to the disease caused by *Glomerella*. It still remains to be determined, however, whether some of the so-called anthracnoses are caused by *Glomerella* or not, as the complete life histories of the organisms are not all definitely known at present.

This genus of fungi is of vast economic as well as scientific importance. Few fruits are free from its attacks, and it is known to occur on a great variety of other hosts, from the palms to the highest flowering plants. It is also cosmopolitan in its distribution, though most abundant in temperate and tropical regions.

All the facts connected with the life history of a parasite, the causes of its variability, its behavior under different conditions, and its relation to different hosts are essential to the most comprehensive and successful development of practical methods for the prevention and control of disease.

The primary objects of this investigation have been to determine the life histories and habits and the identity or relationship of the forms of *Gloeosporium* and *Colletotrichum* found upon the same hosts and on different hosts. Attention has also been given to the physiological features of the fungi and the possibility of their passage from one host to others. Careful studies of pure lines or races originating from single ascospores and single conidia have been carried on through many generations in order to determine, if possible, the conditions affecting the production of the ascogenous stage and the causes of the variations which sometimes appear in pure cultures.

¹ The numbers appearing in parentheses in this bulletin refer to the list of literature cited on pp. 101-105.

The first production of perithecia of *Glomerella* in pure cultures, so far as records have been found, was by Atkinson, as reported by Stoneman (89) in 1898. This ascogenous form was named *Gnomoniopsis cingulata* Stonem. (89). The conidial form had been described by Atkinson (2) as *Gloeosporium cingulatum*. Since Miss Stoneman's work was done considerable study has been given by different investigators to the life histories and relationships of *Gloeosporium* and *Colletotrichum* occurring upon different hosts. The systematic study and segregation of the species in this group of organisms has usually been based upon the supposed fixity of their host relationships and on some slight but inconstant differences in their morphological characters. A form occurring on a certain host was generally assumed to be distinct from one occurring upon another host, especially if there happened to be some slight difference in the measurements of the few spores observed or in the appearance of the affected portion of the host. Later, slight differences in the last two particulars led to the segregation in some cases of several species from the same host plant. Species were also sometimes based primarily upon the occurrence of the fungus upon different parts of the host. If the fungus at hand happened to occur upon the fruit it might be regarded as distinct from a form which was found upon the foliage or upon a shoot or branch of the same host. It is therefore necessary, before any satisfactory understanding or designation of these organisms can be obtained, to determine not only the ordinary range of variability of their morphological characters and their complete life histories, but also their host relationships. Where no fairly constant morphological characters can be found to separate the forms growing upon different portions of the same host plant, they should without question be referred to the same species. Where they occur upon different hosts, but still show no reasonably constant characters for identification and separation, they should still be regarded as one species. If it be held that these latter should be separated as so-called physiological species, the burden of proof falls upon those who take that position. Such a position can only be sustained by a sufficient number of successful cross-inoculation experiments to demonstrate that the organism will not pass from one host to another.

The present paper covers the investigation of members of this group of organisms obtained from 45 different host plants.

PREVIOUS INVESTIGATIONS.

Previous work with these organisms may be divided into two parts: That primarily of a systematic or taxonomic character and that chiefly concerned with cultural, cross-inoculation, and life-history studies.

The conidial form of this genus of fungi is apparently much more common, conspicuous, and likely to be observed than the perithecial form. For this reason the majority of the species are much better known in their conidial condition than in any other and have been described principally under the names *Gloeosporium* and *Colletotrichum*, though some have apparently been referred to *Cylindrosporium*, *Marsonia*, and other similar genera. Four hundred and seventy-three species of *Gloeosporium* and *Colletotrichum* are given by Saccardo. This does not, as already suggested, include all of the species or forms that belong to this group, as some are found under other generic names. On the other hand not all the forms or species described under *Gloeosporium* and *Colletotrichum* are conidial stages of *Glomerella*.

It is quite certain, from a study of specimens and a comparison of the descriptions, that about 50 per cent of these so-called species can not be separated except on the basis of host relations or part of the host attacked. No monographic treatment of *Gloeosporium* and *Colletotrichum* has yet been attempted. The compilation of descriptions undertaken by Ellis and Everhart (33), in the *Journal of Mycology*, and that of Saccardo (67), in *Sylloge Fungorum*, are practically all we have.

Cross-inoculation experiments have been carried on at different times by different investigators. Owing to the various methods practiced in different cases and in some instances the lack of record of sufficiently definite information as to the details of the work, it is difficult satisfactorily to compare and coordinate the results. Southworth (84), Halsted (39, 40, 41), Cobb (20, 21), Clinton (19), Burrill (15), Edgerton (28, 29, 30, 31), Sheldon (77, 79), Chester (18), and Taubenhaus (90, 91) have made the principal contributions to this phase of the subject. A discussion of these results accompanied by tables will be found on subsequent pages.

Considerable attention has already been given by different investigators to cultural and life-history studies of these organisms. Among these may be mentioned the work of Southworth (84, 85), Atkinson (2), Stoneman (89), Clinton (19), Edgerton (28, 29, 30, 31, 32), Lasnier (55), von Schrenk and Spaulding (70), Sheldon (77, 78, 79, 80, 81), Shear (74), Barre (7, 8), Shear and Wood (75, 76), Koorders (54), and Scott (73). The work of Klebahn (51, 52) on *Gloeosporium* relates to species which are not congeneric with *Glomerella*.

PRESENT INVESTIGATION.

The present investigation was commenced by the senior writer in 1904. A brief summary of the early part of the work was published by the present writers (75) in 1907. At that time the life histories of the forms of *Glomerella* found on eight different hosts were briefly

reported. During the same year a detailed description of the life history and behavior in cultures of *Glomerella rufomaculans vaccinii* Shear (74) was given by the senior writer in connection with a general discussion of cranberry diseases. In 1908 the present writers (76) presented a summary of their work before the Botanical Society of America, a brief abstract of which appeared in 1909. At that time the life histories of forms obtained from 18 different hosts had been worked out. Since then the number has been doubled, and both the conidial and ascogenous stages of *Glomerella* from 36 different hosts have been studied and the conidial forms from 45 different hosts have been grown, as follows:

GLOMERELLA CINGULATA (STONEM.) S. AND V. S.

Conidia and perithecia produced either in culture or on the host:

Brya ebenus (L.) DC. (Jamaica ebony).	Hedyscepe sp. = Kentia (palm).
Caryota rumphiana Mart. (palm).	Ligustrum vulgare L. (privet).
Cinnamomum zeylanicum Nees (cinnamon).	Malus sylvestris Mill. (apple).
Citrus aurantium sinensis L. (sweet orange).	Mangifera sp. (mango).
Citrus decumana (L.) Murr. (pomelo).	Maranta arundinacea L.? (arrowroot).
Citrus limonum Risso (lemon).	Oxycoccus macrocarpus (Ait.) Pers. (cranberry).
Citrus nobilis Lour. (mandarin).	Persea gratissima Gaertn. f. (avocado).
Coffea arabica L. (coffee).	Phormium tenax Forst.
Costus speciosus (Koenig) Smith (spiral flag).	Pimenta acris (Swartz) Kostel.
Curculigo sp.	Piper macrophyllum Swartz (peppercorn).
Eriobotrya japonica (Thunb.) Lindl. (loquat).	Pitcairnia corallina Linden.
Ficus carica L. (fig).	Psidium guajava L. (guava).
Ficus elastica Roxb. (rubber plant).	Ribes oxycanthoides L. (gooseberry).
Ficus longifolia Schott.	Rubus occidentalis L. (black raspberry).
Ginkgo biloba L.	Thea japonica (L.) Baill. (camellia).
Gleditsia triacanthos L. (honey locust).	Thea sinensis L. (tea).
	Theobroma cacao L. (chocolate nut).
	Vitis labrusca L. (Concord grape).

Conidia only produced:

Annona cherimola Miller (cherimoya).	Smilax medica Schl. and Cham.
Crataegus sp. (hawthorn).	Vanilla planifolia Andrews (vanilla).
Rubus trivialis (cult.) (white dewberry).	

GLOMERELLA GOSSTYII EDGE.

Both conidia and perithecia produced in cultures:

Gossypium hirsutum L. (cotton).

GLOMERELLA LINDEMUTHIANUM SHEAR.

Both conidia and perithecia produced in cultures:

Phaseolus vulgaris L. (wax bean).

GLOEOSPORIUM LAGENARIUM (PASS.) SACC. AND ROUN.

Conidia only produced:

Citrullus vulgaris Schrad. (watermelon).	| Cucurbita pepo L. (squash).
Cucumis sativus L. (cucumber).	|

GLOEOSPORIUM MUSARUM CKE. AND MASS.

Conidia only produced:

Musa paradisiaca sapientum (L.) Kuntz (banana).

METHODS OF STUDY.**DEVELOPMENT IN MOIST CHAMBER.**

Apparently normal and healthy leaves, twigs, and fruits taken from plants showing a slight infection or suspected of being infected with anthracnose in a dormant or hibernating condition were found in most cases to develop typical spots of rot with acervuli and frequently perithecia when kept in a moist chamber. Such material was first immersed from 5 to 15 minutes in a 1 to 500 or 1 to 1,000 solution of corrosive sublimate to destroy any spores of the fungus which might be present. That this treatment is sufficient to destroy all the known reproductive bodies of *Glomerella* has been demonstrated by treating conidia, appressoria, and ascospores with these solutions for different periods. Treatment with a 1 to 1,000 solution of corrosive sublimate for three minutes has been found to kill all the spore forms.

After the foregoing treatment the specimens were rinsed in sterile water and placed in sterile glass moist chambers.

CULTURES.

Cultures have usually been started from conidia or ascospores obtained from fresh material from the field or greenhouse or from spores developed on parts of the host kept in a sterile moist chamber in the laboratory. To obtain pure cultures of the organism and to isolate single spores, poured plates of corn-meal agar have been generally used. Various solid or liquid media have been tried, but none has proved more satisfactory than corn-meal agar, which is prepared as follows: To four teaspoonfuls of corn meal add 1 liter of distilled water. Keep in water bath for one hour at a temperature below 60° C. Strain through gauze and to the filtrate add 1 per cent of agar flour. Steam three-quarters of an hour. Filter through filter paper. Tube and autoclave for 15 minutes at 115° C.

In isolating single spores to obtain pure-line cultures, special Petri dishes with very thin bottoms are used. After the plates have been poured and the agar cooled, the dishes are placed upside down on the microscope stage and single spores located with an objective of suffi-

cient power to distinguish and identify them clearly through the bottom of the dish. The location of the single spores is then indicated by a small circle of red ink on the bottom of the Petri dish. The culture medium in the dish should be very shallow, so that the range of the objective will reach through the full depth of the medium and permit the detection of spores lying at different levels. Some practice in getting the proper dilution of the spores in the medium is required. When the spores are too numerous in the plates it is frequently difficult to find one sufficiently isolated to be readily removed without the possibility of others being transferred with it. When the spores are too few, however, much time is required in searching over the plate to locate them.

Spores have also been isolated by the method described by Kauffmann (50). This method consists in sprinkling sterile water containing the spores on the surface of the agar after it has been poured in a Petri dish and cooled. When the medium has solidified, the spores are located with the microscope by examining the surface of the agar with the cover of the dish removed. This method has the advantage of insuring the distribution of the spores in practically one plane—i. e., on the surface of the medium—and permitting the use of a higher power objective than could be used when searching through the bottom of the dish. It has the disadvantage, however, of necessitating the removal of the cover during the search for the spores and thus greatly increasing the liability of contaminating the culture; but this tendency can be largely overcome by making the examination in a thoroughly protected culture room. With thin dishes and a thin layer of culture medium, spores not less than eight microns long can be located very satisfactorily by the first method. With smaller spores requiring high power for identification, the second method is preferable. As soon as the spores have germinated, which usually requires 8 to 16 hours, they are carefully transferred by means of flattened sterile needles to tubes of the same medium. If the germinating spore is transplanted near the upper margin of the agar and close to the wall of the tube, it may be usually located with the microscope and its actual transfer to the tube verified.

Pure lines, races, or strains can be isolated in this manner, then propagated indefinitely by transfer to subcultures or by the poured-plate method, thus making it possible to study the behavior of the organism in relation to various factors of nutriment and environment through as many generations as is desired.

STUDIES OF GLOMERELLA FROM DIFFERENT HOSTS.

The following records give the results of the writers' studies of *Glomerella*, *Gloeosporium*, and *Colletotrichum* from various host plants, describing their behavior on leaves, stems, and fruits in

moist chamber and also in pure cultures. This matter is arranged alphabetically with reference to the host plants. Following the name of the host in each case is the name which has been adopted for the organism, with synonyms also where they have been satisfactorily determined.

ANNONA OHERIMOLA MILL. (OHERIMOYA).

Gloeosporium rufomaculans (Berk.) Thüm.

Poured plates of conidia from an acervulus on a stem of cherimoya received from Miami, Fla., were made on April 9. Growth was rapid. The mycelium was white at first, changing later to dark greenish or smoke color and forming circular spots. Subcultures on corn-meal agar in tubes produced an abundant growth of mycelium and acervuli with a few setæ. Later many setæ appeared in these cultures. Though the cultures were kept growing until January 19 of the following year, no perithecia were ever found. The fungus from this host does not appear to have received a specific name. The characters of the acervuli and the shape and measurements of the spores averaged about the same as those from the apple, grape, and citrus fruits.

BRYA EBENUS (L.) DC. (JAMAICA EBONY).

Glomerella cingulata (Stonem.) S. and v. S.

Several leaves of the host plant, collected in the greenhouse on January 19, were placed in sterile moist chamber. On February 8 acervuli of *Gloeosporium* were present on several of the leaves. On February 17 many mature perithecia were found associated with the acervuli. An ascus and ascospores are shown in Plate II, figures 23 and 23 a. The fungus showed no characters by which it could be distinguished from the *Glomerella* on apple and grape. No fungus of this kind appears to have been heretofore reported upon this host.

Plates were poured February 8, using conidia from a leaf taken from an apparently healthy plant in the Department greenhouse. The acervuli from which these cultures were made developed upon this leaf in a sterile moist chamber. Spores germinated quickly and subcultures in tubes of corn-meal agar were made by transferring single conidia. Growth in the plates was similar to that usually produced by *Gloeosporium* from apple or grape. Conidia were produced in both plates and tubes, but no very distinct acervuli were found. On February 17 the cultures were found to be contaminated with a mold and had to be discarded. Perithecia were not found in them. The cultures were perhaps not old enough at the time for perithecia to have had an opportunity to develop.

CARYOTA RUMPHIANA MART. (PALM).

Glomerella cingulata (Stonem.) S. and v. S.

On January 29 leaves from a plant of this species, which was growing in the greenhouse and which had produced leaves with spots showing conidia of *Glomerella*, were placed in a sterile moist chamber. On February 3 a number of the leaves showed acervuli with conidia ranging from 13.5 to 25 by 4.5 to 6 μ . Setæ were present but not abundant. The conidiophores appeared to average a little shorter than is usual with forms from other hosts, being 9 to 15 μ in length. On February 18 many mature perithecia agreeing in practically all respects with *Glomerella cingulata* were found on these leaves. Asci and ascospores are shown in Plate II, figures 28 and 28 a.

The conidial form has apparently been described as *Gloeosporium nanoti* Prill. and Delacr. (64).

On February 7 cultures in corn-meal agar tubes were made by transfer of spores from acervuli on the leaves in moist chamber just described. Typical conidia and acervuli were formed in a few days. These cultures were kept until July 7, but no perithecia were ever found.

CINNAMOMUM ZEYLANICUM NEES. (CINNAMON).

Glomerella cingulata (Stonem.) S. and v. S.

Leaves appearing perfectly healthy, taken from a greenhouse plant of this species, were placed in moist chamber. The leaves soon became discolored and several acervuli with conidia appeared. The conidial form agrees with *Gloeosporium ochraceum* Patterson (62).

On February 11 transfers of conidia were made from these acervuli to corn-meal agar tubes. These produced large acervuli and appressoria. Though kept until July 7 no perithecia were ever found. On April 30 more plates were poured from conidia from a leaf kept in moist chamber. A few peritheciump-like bodies were found in the plates on May 15. On May 23 some of these plates showed perithecia with mature asci. Subcultures to corn meal in flasks were made from the original tubes. These produced very few conidia but many sterile peritheciump-like bodies. Chlamydospores were also present. No asci were found in these cultures.

CITRULLUS VULGARIS SCHRAD. (WATERMELON).

Gloeosporium lagenarium (Pass.) Sacc. and Roum.

On November 17, plates were poured, using conidia from an anthracnose spot on a watermelon grown at Vienna, Va. Transfers from plates to corn-meal agar tubes were made. Numerous acervuli soon

appeared in these plates and very dark setæ were present in abundance. The setæ, however, were dark only at the apex and light colored at the base, which is not the case with the setæ in most other forms. They also appeared to be somewhat shorter than usual. No perithecia or peritheciumlike bodies appeared in the cultures.

The fungus agrees with *Gloeosporium lagenarium* (Pass.) Sacc. and Roum. It seems probable that the fungus occurring on cucurbits is specifically distinct from the other species investigated, though Halsted (40) reports the successful transfer of the organism from bean and pear to citron, *Citrullus vulgaris* var. He also reports the successful transfer of the organism from watermelon to bean, and as a result reduces *Colletotrichum lindemuthianum* to synonymy, using *Colletotrichum lagenarium* (Pass.) E. and H., which is the older name, for anthracnose of bean as well as that of cucurbits. Evans (36) states that the fungus passes from bean to watermelon and vice versa, but the statement is apparently based upon Halsted's work (39) and not on his own experiments. Further cultures and the opportunity to study the perithecial form from watermelon may be necessary to determine this point satisfactorily. The experiments of Edgerton (30) and the present writers in attempting to transfer the organism from bean to cucurbits, as reported later, were all failures. The writers' inoculations with the form from grape and guava to watermelon, however, were entirely successful, but not conclusive as to the identity of *Colletotrichum lagenarium* and *Glomerella cingulata*, since the perithecial stage of the former is unknown.

CITRUS AURANTIUM SINENSIS L. (SWEET ORANGE).

Glomerella cingulata (Stonem.) S. and v. S.

Colletotrichum gloeosporioides Penz.

DEVELOPMENT ON LEAVES AND BRANCHES IN MOIST CHAMBER.

Since the fungus appeared to be present in a dormant or hibernating condition in the tissues of the leaves, as indicated by its appearance on apparently healthy leaves when their surfaces were thoroughly sterilized and placed in sterile moist chamber, several attempts were made to secure data which might throw some light upon the location of the fungus in the tissues and its original point of entrance. On March 6 apparently healthy leaves of various ages were taken from a blossoming tree in the greenhouse. These were treated as usual and placed in sterile moist chambers. On March 14 numerous acervuli were present on all the leaves except the youngest, which showed a number of discolored spots but no other external evidence of fungous infection. The acervuli on the older leaves usually appeared first at the base of the midrib, being preceded by a dark, water-soaked appearance of the tissue. In some cases the diseased

area gradually spread toward the tip until the entire leaf was affected, as illustrated in Plate VI. At other times acervuli broke out almost simultaneously on the entire surface and were equally numerous both on the upper and under sides of the leaf. On March 25 all but the present year's leaves, which were not entirely discolored, were covered with the fungus. Small patches of mature perithecia were also present. Though kept until April 13, the young leaves showed no trace of acervuli or perithecia of *Glomerella*.

On April 30 two more apparently healthy leaves were taken from near the tip of a shoot bearing fruit one-half inch in diameter. These were sterilized and placed in moist chamber, and two leaves from the previous season's growth on the same branch were treated in the same way. On May 7, acervuli were abundant on the older leaves. On one, development was chiefly along the midrib; on the other, chiefly along the margins. The younger leaves showed no acervuli. On May 11 one of the younger leaves showed discoloration and a few acervuli at the base of the midrib. The other young leaf showed discoloration at the base, but had developed no acervuli on May 13 when the leaves were discarded.

On May 11 a young sterile shoot—that is, a shoot without a fruiting bud—was taken from a greenhouse plant and the surface thoroughly sterilized as usual. It was then cut into six segments, each one bearing a single leaf. Each segment was placed in a separate sterile moist chamber. This experiment was performed to determine whether the fungus was equally abundant in fruiting and nonfruiting shoots; that is, whether the fungus might possibly enter the flower and gradually work back into the older parts of the shoot and foliage. These segments were numbered 1 to 6, beginning at the basal end. On May 18 all six leaves were more or less discolored, numbers 1 to 4 less than the others. In all cases the discoloration spread from the base of the leaf toward the apex. All but No. 2 bore acervuli. On May 27 all the leaves were entirely discolored and almost covered with acervuli. The portions of the stem also showed acervuli. Since leaves 5 and 6, which were near the apical end of the shoot and youngest, became discolored slightly sooner than the older ones, it might, perhaps, be inferred either that they were infected earlier or that the tenderer tissues furnished more favorable conditions for rapid development.

On May 11 an apparently healthy fruiting shoot from the greenhouse was sterilized as usual and cut in segments which were placed in separate sterile Petri dishes. These segments were numbered 1 to 15, beginning at the basal portion of the shoot, as indicated in figure 1.

On May 18 the leaf on segment No. 1 was almost entirely covered with acervuli. The portion of the stem to which it was attached

showed no signs of the fungus. Segment No. 2 showed no indication of the fungus on either leaf or stem; No. 3 showed a slight uniform discoloration of leaf only; No. 4 showed discoloration of the leaf along the midrib and a very few acervuli. Three young fruits on this portion were also discolored and acervuli abundant on the calyx of one; also on the leaf petiole. No. 5 showed discoloration of the basal portion of the leaf and of the stem only. Nos. 6 and 7 showed leaf and stem almost entirely discolored, but no acervuli. In No. 8 the basal portion of the leaf was discolored and a slight discoloration appeared on one side of the leaf, but no acervuli were present. No. 9 showed acervuli on the stem, but the leaf was not discolored. No. 10 had the entire leaf discolored. No. 11 showed the leaf almost wholly discolored, with the fruit black and bearing acervuli. On No. 12 the leaf and stem were almost entirely discolored, with acervuli at the base of the leaf. No. 13 showed the fruit completely discolored and acervuli present, but the leaf was not discolored. No. 14 showed the leaf entirely discolored, with acervuli on the cut surfaces of the stem. In No. 15 the leaf was almost entirely discolored, but no acervuli were present.

On May 20 leaves on Nos. 2 and 9 were still a normal color; all others, except 11 and 13, which were entirely discolored, showed abundant acervuli. Acervuli were present on all the fruits. On May 25 Nos. 2 and 9 had become discolored and showed abundant acervuli. Acervuli were also abundant on Nos. 11 and 13.

As a result of this experiment it will be noted that the fungus was present in all the leaves of the new growth as well as on the growth of the previous year. The fungus developed more rapidly on the older leaves. The early and vigorous development of the fungus in the young fruits and the leaves situated at their bases and the rather tardy development of the fungus in leaves remote from the blossoming shoots—that is, Nos. 2 and 9—seems to indicate a downward course of development of the fungus and infection by way of the blossoms, as shown by Rolfs (66) and Bessey (12).

CULTURES.

Numerous cultures have been made from conidia and ascospores obtained from orange leaves. Apparently healthy, vigorous orange

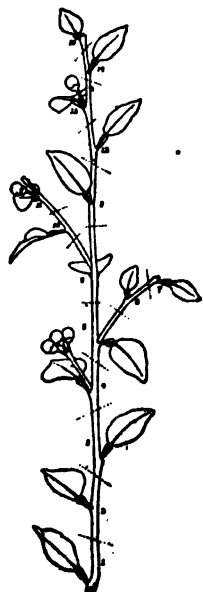


FIG. 1.—An apparently healthy fruiting branch of an orange taken from a greenhouse plant, divided into 15 parts as indicated, then washed thoroughly in corrosive sublimate solution and kept in sterile moist chambers. *Glomerella cingulata* developed on all the leaves and fruit in such a manner as to indicate a probable origin from infection of the blossoms.

leaves taken from greenhouse plants have frequently been treated with corrosive sublimate and placed in sterile moist chambers. Such leaves have almost invariably produced an abundant growth of acervuli, which is frequently followed by the development of perithecia with typical asci and ascospores. The time required for the development of perithecia is usually two to four weeks.

Poured plates made with conidia from leaves kept in moist chamber produced a growth very similar to that obtained from other hosts. The number, size, and distribution of the acervuli formed vary considerably. Setæ were not usually present in these plates. Several series of plates produced only conidia. Two showed a few peritheciumlike bodies, but no asci were found. Different tubes showed considerable difference in the appearance of the growth. In some it was light colored and scanty; in others, abundant and dark.

Cultures were made from conidia taken from an orange leaf received from Houston, Tex., March 10, which was treated as usual and kept in sterile moist chamber until March 29. Transfers of single germinating conidia to corn-meal agar tubes were made. The growth was of a smoky-brown color, resembling that of cultures from pomelo hereafter described. A few large acervuli were formed, but no perithecia, though perithecia were produced on leaves in moist chamber. Later, setæ were found in abundance.

CITRUS DECUMANA (POMELO).

Glomerella cingulata (Stonem.) S. and v. S.

Colletotrichum gloeosporioides Penz.

DEVELOPMENT ON LEAVES IN MOIST CHAMBER.

On March 28 apparently healthy leaves of the pomelo were taken from greenhouse plants and placed in sterile moist chambers. They soon became spotted and acervuli appeared. These were soon followed on darker areas of the discolored leaf by perithecia, which showed mature asci on June 20. Setæ were not found in the acervuli on these specimens.

On April 30 two apparently healthy leaves were taken from immediately below a cluster of young fruit; also an older leaf, from whose axil a fruiting shoot was produced. These leaves were treated as usual and placed in sterile moist chambers. On May 7 acervuli were found regularly scattered over the surface of the older leaf, but there were none on the two young leaves. On May 13 the base of one of the young leaves showed slight discoloration running up the midrib three-fourths of an inch. On May 15 both young leaves were discolored along the midrib. Acervuli developed abundantly on these young leaves later. On June 9 perithecia and asci were found on the old leaf. This experiment, like those with the orange, apparently showed the presence of

the fungus in the tissues of both young and old leaves, but it is either more widely distributed in the old leaves or else develops in them more rapidly, as discoloration of the leaves and fructification of the fungus appeared sooner in most cases on old leaves.

On May 16 one of the young fruits about three-fourths of an inch in diameter was taken from the branch just above the two young leaves already referred to, the surface sterilized, and placed in a sterile moist chamber. On May 27 acervuli of *Glomerella* were found on the inside of the calyx and also on the fruit.

On March 6 other apparently healthy leaves, both young and old, were collected from a blossoming tree in the greenhouse, treated as usual, and placed in sterile moist chambers. Eight days later the 1-year-old and 2-year-old leaves showed abundant acervuli developing along the midrib, as indicated in Plate IV. The very young leaves in this instance showed no indication of the fungus. Ten days later the 1-year-old and 2-year-old leaves showed a number of discolored areas with perithecia. In this case the areas producing conidia and those producing perithecia were separate but contiguous, the two forms together almost covering the entire surfaces, as shown in Plate V. The young leaves now began to show discolored areas but no signs of fungous growth. On April 14 the youngest leaves were still free from any sign of fungus.

Other old leaves collected January 29 and treated as usual also developed an abundance of acervuli and perithecia.

CULTURES.

On March 16 cultures were made from conidia found on a fruit of pomelo received from Miami, Fla. Setæ were abundant in the acervuli on the fruit. The fungus grew rapidly, producing a smoky-colored growth like that in some of the cultures from the orange. Large acervuli were produced bearing a very few setæ. No perithecia were ever found in these cultures.

On May 14 other cultures were made from a pomelo fruit from Bonita, Cal. These cultures were made by transplanting portions of discolored spots or so-called "tear stains" from the fruit. The surface of the fruit was sterilized as usual with corrosive sublimate. The resulting growth was apparently pure and produced an abundance of acervuli and peritheciumlike bodies. These cultures were kept until August 13, but no asci or spores were found.

On June 17 corn-meal agar plates were poured, using conidia from acervuli surrounded by ascogenous perithecia from a leaf in moist chamber. These cultures all produced acervuli. They were kept until July 22 but showed no perithecia. No setæ or chlamydospores were seen in these cultures.

CULTURES FROM ASCOSPORES.

On June 25 poured plates were made with ascospores taken from a portion of a leaf in moist chamber which was producing perithecia only. A single ascospore was isolated and transferred to a slant agar tube.

On July 22 one plate showed a few perithecia with immature asci. No conidia were found. The tube culture from a single ascospore developed only a hyaline sterile mycelium and chlamydospores. Transfers from this tube to corn-meal flasks produced an abundant growth of white mycelium, which later became pinkish. On July 22 a very few spores, apparently conidia, were found. No typical acervuli or perithecia were produced in these cultures and it might possibly be suspected that the ascospores used did not really belong to *Glomerella*. They were, however, typical in appearance and morphological characters, and their identity could scarcely be doubted. The cultures from the ascospores on pomelo leaves did not produce, as is usually the case, many ascogenous fructifications. Only a few perithecia with spores were produced. Conidia were also scattered. No setæ were found, but chlamydospores were usually present. The ascospores from leaves in moist chamber varied from 18 to 23 by 4.5 to 6 μ . Asci were 60 by 10.5 to 12 μ . Paraphyses were found. The conidia from these cultures varied from 12 to 24 by 5 to 6 μ . Conidia from the leaves in moist chamber varied from 13.5 to 21 by 4.5 to 7 μ .

CITRUS LIMONUM RISSO. (LEMON).

Glomerella cingulata (Stonem.) S. and v. S.

DEVELOPMENT ON LEAVES IN MOIST CHAMBER.

Leaves of lemon taken from a plant in the greenhouse and showing small discolored dead spots bearing a few conidia were placed in a sterilized moist chamber. An abundance of acervuli soon developed over both surfaces of the leaves. A few setæ were found. No perithecia were produced on these leaves.

On January 29 another leaf spotted in the same way and showing acervuli was placed in a moist chamber. On February 19 the leaf was almost covered with acervuli. A few setæ were present. A few areas bore perithecia agreeing in every respect with those found on leaves of other citrus species under similar conditions.

On January 29 three leaves apparently perfectly healthy were sterilized as usual and placed in a sterile moist chamber. On February 11 acervuli were present on the largest leaf, occurring mostly along the midrib and the larger veins. On February 15 this leaf had grown much darker and many acervuli were present. The other two leaves showed no signs of a fungus except that the petiole of one bore

a few acervuli. On April 7 abundant acervuli and perithecia had developed on all the leaves.

On April 30 two apparently healthy normal leaves were taken from a greenhouse plant just below an unopened flower bud, and a single leaf also was taken from the old wood lower down on the same branch. These leaves were sterilized as usual and placed in sterile moist chambers. On May 14 the old leaf showed discoloration extending from the base of the midrib to within half an inch of the tip, but no acervuli were present. On May 16 the end of the shoot from which the two leaves had been taken was cut off and placed in moist chamber. This shoot bore a young fruit about one-third of an inch in diameter, which had developed since the leaves were removed. The leaf next below these two was also taken and placed in moist chamber. On May 26 the old leaf showed acervuli. The two from below the unopened bud were still normal in appearance except for a slight discoloration at the base of the midrib extending up about three-fourths of an inch. The young fruit was also discolored, discoloration beginning at the stigma and working back. No acervuli or perithecia developed on the two young leaves and the fruit.

Since the foregoing was written, Essig (35) has recommended placing leaves in moist chamber to determine the presence of this fungus in lemon groves.

CULTURES.

On December 12 two plates were poured, using conidia from a lemon leaf in moist chamber. On December 17 an abundant growth was present in the two plates, which differed greatly in appearance, though both appeared to be pure cultures. In one the mycelium was colorless and uniformly distributed over the surface showing many minute acervuli. Brown chlamydospores had also formed against the surface of the glass. No setæ were found. In the other plate the mycelium was slightly colored and denser, with dark points suggesting the beginnings of perithecia. No spores were yet found in this plate. On January 14 acervuli were thickly and uniformly distributed over the surface of the first plate and a few large acervuli were present in the second plate. Setæ were also found in the second plate but none in the first. No perithecia developed in either. Subcultures made from both plates to flasks of corn meal made a growth which was identical in appearance and produced an abundance of pink acervuli. No perithecia were found.

On December 18 four plates were poured, using conidia from four separate acervuli from the same leaf in moist chamber. Numerous acervuli developed in all, showing a tendency to form about cavities in the agar where portions had been removed for subcultures. This behavior was also shown in plates made from the orange, but was not noticed in the other plates from lemon.

On May 28 cultures were made in five flasks of corn meal by transplanting a portion of the discolored epidermis, the so-called "tear-stain," of a lemon received from Bonita, Cal. The surface of the lemon had been sterilized by thorough washing with corrosive-sublimate solution. Appressoria or chlamydospores of *Gloeosporium* were found on the surface of the discolored skin. On June 2 the five flasks apparently contained pure cultures of *Glomerella* and were identical in appearance with those made in the same way from pomelo. Conidia were abundant, but no setæ were seen.

In discussing the diseases of the lemon caused by this fungus in California, Essig (35) states that the most satisfactory method of controlling them yet tried is by spraying with 4-4-50 Bordeaux mixture. This statement also accords with the results of Rolfs (66).

CITRUS NOBILIS LOUR. (MANDARIN).

Glomerella cingulata (Stonem.) S. and v. S.

DEVELOPMENT ON LEAVES IN MOIST CHAMBER.

On January 29 four apparently healthy leaves from greenhouse plants were treated as usual and placed in a sterile moist chamber. On February 11 acervuli of *Glomerella* were present on all, having developed first at the base of the midrib. On February 29 a few perithecia with ascospores were found. Perithecia of the same *Glomerella* were also found on spotted leaves from the same plant, which had been kept in moist chamber.

CULTURES.

On March 20 two tube cultures were made from acervuli on the leaves in moist chamber. These cultures produced a growth of normal appearance, with acervuli but no perithecia. On October 7 two plates were poured, using conidia from a leaf in moist chamber. These plates produced an abundance of acervuli. A very few setæ were found. Setæ had also been found on the leaves from which the cultures were made but they were not numerous. Subcultures from these plates also produced an abundance of acervuli, but no setæ were seen and no perithecia ever developed, though perithecia with immature asci were found on the leaves from which the original cultures were made.

On November 14 subcultures on corn meal were made from the tubes just described. Many large acervuli soon formed. The spore masses frequently ran together and formed pink masses covering about one-half the surface of the medium. Dark spots resembling perithecia were also present but no asci or ascospores could be found. These cultures were kept until the following March, but no fertile perithecia were found and no setæ were observed.

It will be noted that perfect perithecia and asci of *Glomerella* were frequently produced upon leaves of the various citrus species when placed in a moist chamber. It is therefore somewhat remarkable that in only one case, that of the pomelo, were we able to get perithecia to develop in cultures.

The fungus from all the citrus hosts showed very similar characters in cultures and can not be distinguished from that on most other fruits. When old the mycelium is usually of a dark greenish or smoky color. The form of the fungus growing on citrus species has apparently been described several times under different names in both its conidial and ascogenous conditions. The conidial form has been treated by Rolfs (66) and others as *Colletotrichum gloeosporioides* Penz. (63). To judge from the descriptions and figures, it has also received several other generic and specific names. The conidia have been found to vary from 11 to 19.5 by 4.5 to 6 μ . The ascospores vary from 16 to 19 by 4.5 to 6 μ .

The perithecial form has apparently been described under several different names, including *Physalospora citricola* Penz. It is also found under *Laestadia socia* Penz.

COFFEA ARABICA L. (COFFEE).

Glomerella cingulata (Stonem.) S. and v. S.

DEVELOPMENT ON LEAVES IN MOIST CHAMBER.

On December 4 leaves showing dead spots but no acervuli were taken from a coffee plant in the greenhouse. The surfaces were sterilized as usual and the leaves placed in a moist chamber. On December 30 acervuli and mature perithecia of *Glomerella* were found on these leaves. Setæ were present in the acervuli.

On January 29 two apparently healthy young leaves of the same age were treated in the same manner and placed in a sterilized moist chamber. On February 13 numerous acervuli were present on a discolored area, which extended downward from the tip of one of the leaves. The other leaf was entirely discolored but no acervuli were present. Later, perithecia of *Glomerella* were found associated with the acervuli on both leaves.

CULTURES.

On December 12 plates were poured using conidia from the leaves in moist chamber, on which perithecia developed later. A single conidium was located in one plate and transferred to a tube. On December 19 one plate had become contaminated and was discarded. The other contained a growth of the fungus of the usual appearance. Conidia were found. On December 26 acervuli were present in abundance in the tube and also in the plate. No setæ or perithecia were found. On January 8 two flasks of corn-meal agar were inocu-

lated by transfer of conidia from the tube culture from the single conidium mentioned above. On January 20 an abundant greenish growth was present, and many dark bodies resembling perithecia were forming. Many acervuli were also present. No setæ were found and no perithecia ever matured sufficiently to show asci and ascospores.

On June 12 two slant agar tubes were made by transfer from the single conidium culture. These tubes produced a growth of the usual appearance and small acervuli formed, but no perithecia were ever found.

The growth and appearance of the conidial form from the coffee closely resembles that from other hosts, especially the Citrus species. Setæ and perithecia developed on the leaves in moist chamber but neither were found in the cultures made from the same leaves. The conidia from the leaves in moist chamber measured 13.5 to 16.5 by 5 to 6 μ . The conidia in culture varied from 15 to 18.5 by 4.5 to 6 μ . The ascospores from the leaves (Pl. I, figs. 14 and 14a) measured 15 to 18 by 5 to 6 μ . No paraphyses were found. The perithecial form found on the leaves suggested *Laestadia coffeicola* Speg. (86). The ascospores of this species are said to be obovate, and the measurements given are rather less than usual in *Glomerella cingulata*. Two species of Colletotrichum and two species of Gloeosporium have been described from coffee leaves. The descriptions of these species show no diagnostic characters sufficient to separate them satisfactorily. *Gloeosporium coffeanum* Delacr. (23) evidently refers to this species also.

COSTUS SPECIOSUS (KOENIG) SMITH (SPIRAL FLAG).

Glomerella cingulata (Stonem.) S. and v. S.

On January 30 portions of a leaf showing large dead areas were sterilized as usual and placed in a sterile moist chamber. On February 7 acervuli were found on these leaves, and on February 14 many mature perithecia of *Glomerella* were present. Asci and ascospores are shown in Plate II, figures 21 and 21a. No fungus of this kind in either stage could be found reported on this host.

On February 7 two tube cultures were made by a transfer of conidia from the leaf in the moist chamber, each culture from a different acervulus. On February 24 one large acervulus was present in one tube and a few large sterile dark bodies in the other. On July 7 a few acervuli were present in the second. The perithecial bodies were still sterile and no asci were ever found. The general appearance of the growth in the tubes was much like that of the fungus from other hosts but somewhat lighter colored. The conidia from the specimens in moist chamber showed the usual variations in shape, and they varied in measurement from 12 to 18 by 4.5 to 6 μ . The conidia in

cultures varied from 10 to 16.5 by 4.5 μ . The ascospores from the leaves in moist chamber showed the usual shape and varied from 15 to 21.5 by 5 to 6 μ .

CRATAEGUS SP.

Gloeosporium fructigenum Berk.

On December 12 three flasks of corn-meal agar were inoculated with spores from acervuli on a fruit of Crataegus which had been collected from a tree on the Department of Agriculture grounds and kept in moist chamber. The appearance of the acervuli and the decay of the fruit closely resembled that of the bitter rot of the apple. Conidia developed in these cultures and small dark bodies resembling perithecia were found in all the flasks, but no asci or ascospores were obtained.

CUCUMIS SATIVUS L. (CUCUMBER).

Gloeosporium lagenarium (Pass.) Sacc. and Roum.

On June 20 four plates were poured, using conidia from a cucumber leaf collected at Portsmouth, Va. Two days later transfers were made to slant agar tubes. On July 6 the tubes showed an abundance of acervuli with a dense growth of brown setæ. The cultures became contaminated and no perithecia were formed. No opportunity was offered for a further study of this form and its identity with the others described is therefore uncertain.

CUCURBITA PEPO L. (SQUASH).

Gloeosporium lagenarium (Pass.) Sacc. and Roum.

On October 17 four plates were poured, using conidia from acervuli on a squash. The conidia and acervuli were of the same general appearance as those from other hosts. Setæ were abundant. On October 22 conidia were abundant in all the plates, but were scattered, no distinct acervuli being formed. The conidia were unusually variable in size, ranging from 8 to 30 μ in length. In the thickly sown plates dark bodies suggesting perithecia were abundant. None of these dark bodies were present in the thinly sown plates. These peritheciump-like bodies always remained sterile. Chlamydospores were also abundant. The mycelium was light colored. Later, many acervuli with pale pink masses of conidia developed in the tubes, and also an abundance of the sterile perithecia. The cultures were kept until January 13, but no ascospores were ever found in the perithecia. The writers' cross-inoculations of squash with the fungus from the grape were successful, but this does not necessarily prove that the organisms are the same. No inoculations from the squash to other fruits were made.

OURCULIGO SP.

Glomerella cingulata (Stonem.) S. and v. S.

On January 30 a leaf of this plant from the greenhouse, showing an elongated dead area in the center which bore acervuli of *Gloeosporium* and immature perithecia, was sterilized in the usual manner and placed in a moist chamber. On February 3 many dark spots had appeared on the apparently healthy portions of the leaf. Acervuli soon appeared in abundance, and later, setæ were found. On February 17 many mature perithecia of *Glomerella* were also present. Neither form of this fungus appears to have been heretofore reported on this host.

On February 7 two tube cultures were made by transfer of conidia from the leaf in moist chamber. Acervuli with pinkish masses of conidia soon developed, also chlamydosporelike bodies. No perithecia appeared, and subcultures kept until January 23 produced none. The conidia on the leaves varied from 14 to 16.5 by 4.5 to 6.75 μ . The ascospores measured from 12 to 24 by 5.5 to 6 μ . An ascus and ascospores are shown in Plate II, figures 22 and 22a. No characters could be found either on the host or in the cultures to distinguish this fungus from that occurring upon various other hosts.

ERIOBOTRYA JAPONICA (THUNB.) LINDL. (LOQUAT).

Glomerella cingulata (Stonem.) S. and v. S.

On January 29 an apparently healthy leaf taken from a greenhouse plant which also showed some spotted leaves was treated as usual and placed in a moist chamber. On February 11 the leaf had turned dark brown and a few scattered acervuli were present. On April 8 acervuli were abundantly scattered over the surface. Setæ were sometimes present. No perithecia were found.

On the same date two spotted leaves from the same plant were placed in moist chamber. On February 12 abundant acervuli were present on these leaves. On February 20 perithecia of *Glomerella* were also found on the leaves.

Pure cultures made from acervuli from the leaves in moist chamber produced an abundance of typical acervuli, but no perithecia were ever found. The conidia from the leaves ranged from 12 to 18 by 4.5 to 6 μ ; the ascospores from 15 to 19.5 by 5 to 6 μ . Neither stage of this fungus seems to have been described from this host heretofore. Asci and ascospores are shown in Plate I, figures 11 and 11a.

FICUS CARICA L. (FIG).

Glomerella cingulata (Stonem.) S. and v. S.*Colletotrichum carica* Stevens and Hall.

On April 23 plates were poured with conidia from the fruit of a fig received from Georgia. These plates produced conidia. The general appearance of the growth was very similar to that of the fungus from other hosts. Subcultures in tubes produced large scattered acervuli. Setæ were present but not numerous. No perithecia were found in these cultures.

On May 29 streak cultures were made on slant agar tubes, using conidia from acervuli on a decaying fig received from Norfolk, Va. On June 4 no acervuli were found, but a few perithecia with asci not quite mature had appeared. Later, mature asci were found in one tube. These asci were slightly shorter and broader than the average. Some of them contained only two or four spores. Normal asci and spores were also present, however. Other tube cultures developed later an abundance of typical perithecia. The asci showed a greater variability in size than usual on other hosts. (See Pl. II, figs. 29 and 29a.)

On July 3 cultures were made using conidia from a stem of the fig from Norfolk. An abundance of acervuli were produced in these cultures. Setæ were sometimes present and sometimes apparently wanting. Chlamydospores were also found. The conidial form is evidently *Colletotrichum carica* Stevens and Hall (88), and it can not be distinguished, so far as the descriptions go, from several other species which have been published. This fungus showed no characters, either in culture or on the host, which would serve to distinguish it from forms occurring upon other species of *Ficus* as well as those on other fruits, especially the apple. This identity is also confirmed by the cross-inoculation experiments with apples and grapes described later. Edgerton (31), who apparently studied the same organism, also states that it does not differ in any way from the form on the apple. As a result of numerous measurements of asci and ascospores, we find the asci range from 53 to 115 by 10.5 to 15 μ . The ascospores vary from 13 to 21 by 5 to 7 μ .

FICUS ELASTICA ROXB. (RUBBER PLANT).

Glomerella cingulata (Stonem.) S. and v. S.*Neozimmermannia elasticae* (Zimm.) Koord.

DEVELOPMENT ON LEAVES IN MOIST CHAMBER.

On January 14 apparently normal healthy leaves were taken from a greenhouse plant, treated as usual, and placed in a sterile moist chamber. On January 20 dark spots began to appear on the leaves. On February 14 the leaves were entirely discolored. No acervuli

were present, but a few mature perithecia of *Glomerella* were found. Later, acervuli also developed.

On July 12 another apparently normal healthy leaf was treated in the same manner. On July 20 the under surface of the leaf had become light chocolate brown and was thickly covered with minute acervuli. Somewhat larger, brighter colored ones were found on the petiole and about the midrib. No perithecia were found on this leaf. Many other leaves of this host have been treated in the same manner at different times, usually producing both conidia and ascospores.

CULTURES.

On February 11 streak agar tube cultures were made, using conidia from a leaf in moist chamber. On April 8 perithecia were abundant in one tube, being mostly aggregated in masses about the bases of old acervuli. Appressoria were also abundant on the surface of the glass in the upper part of the tube. Subcultures on corn meal in flasks produced an abundance of fertile perithecia also.

On April 1 bits of leaf bearing mature perithecia with ascospores were transferred to flasks of corn meal. On April 26 an abundant growth of conidia and also mature perithecia were found. Setæ were sometimes found in the cultures but not regularly.

Koorders (54) has investigated this form of the fungus as it occurs in Java. He refers the perithecial form to a new genus, *Neozimmermannia*. There is, however, nothing in his description to separate his fungus from *Glomerella* and specimens of our plant submitted to Dr. Koorders for examination were said by him to be identical with his fungus. The conidial form has been called *Gloeosporium elasticae* Cke. and Mass. It can not be distinguished from the forms found on other *Ficus* spp. The asci were found to vary from 52 to 82.5 by 7.5 to 12 μ . Plate II, figures 18 and 18a, shows an ascus and ascospores.

FICUS LONGIFOLIA-SCHOTT.

Glomerella angulata (Stonem.) S. and v. S.

DEVELOPMENT ON LEAVES IN MOIST CHAMBER.

On November 18 two leaves of *Ficus longifolia* showing small dead areas were taken from a greenhouse plant, treated as usual, and placed in a sterile moist chamber. On December 6 numerous acervuli were present, producing masses of salmon-colored conidia. No setæ were found at this time. On January 4 setæ were present and also perithecia with mature asci and ascospores.

On January 29 another apparently healthy, normal leaf was taken from a greenhouse plant, sterilized as usual, and placed in moist chamber. On February 15 the leaf showed discolored spots of a

dark-brown color and a few acervuli were found. Perithecia were also present, especially along the midrib. Some were single and others aggregated in groups. Mature asci were seen. The perithecia and ascospores were apparently identical with those obtained from other species of *Ficus* and could not be distinguished from the forms of *Glomerella* from various other hosts. Asci and ascospores are shown on Plate II, figures 19 and 19a.

CULTURES.

On December 12 plates were poured, using conidia from leaves in moist chamber. The growth was of the usual character and produced a few acervuli, but no perithecia ever appeared.

On February 3 subcultures from these plates were made in flasks of corn meal. The course of development was as usual, and on February 25 acervuli with pinkish masses of conidia were present. Peritheciump-like bodies were also found on the sides of the flask, but no asci or ascospores could be discovered.

On April 28 plates of different dilutions were poured, using conidia from the cultures just described. On May 4 the plate most thinly sown showed a considerable number of acervuli. The next plate, in which more conidia were used, showed very few acervuli. The third plate, in which a still larger quantity of spores was used, showed many scattered conidia but no acervuli. In the cultures where numerous spores were sown, acervuli were much fewer than in those where the spores were more scattered. This behavior may perhaps have some direct relation to the greater quantity of nutriment available in the case of the thinner sowings than in the other. No perithecia were ever found in these cultures, although perithecia were present on the leaves from which the cultures were made. This may possibly have been due to the fact that both fertile and sterile strains were present on the leaves and the conidia used happened to be taken from acervuli belonging to a nonperithecium-producing strain.

Conidia from leaves in moist chamber varied from 15 to 20 by 5 to 6 μ , averaging slightly thicker than in most of the other forms. Conidia in plates varied from 13.5 to 16.5 by 5 to 6 μ . Ascospores ranged from 15 to 22 by 4.5 to 6 μ . No paraphyses were seen.

GINKGO BILOBA L.

Glomerella cingulata (Stonem.) S. and v. S.

Fallen leaves of this plant taken from the grounds of the Department of Agriculture were washed as usual and placed in a sterile moist chamber. In a short time acervuli of *Gloeosporium* formed on the leaves.

On November 13 potato-plug cultures were made by transferring conidia from the acervuli on the leaves in the moist chamber. On

November 23 an abundance of white mycelium was present in the cultures, also a number of black patches looking like areas of developing perithecia. On December 9 a flask of corn meal in which a subculture had been made from a potato plug showed an abundance of mature perithecia with asci and ascospores, which appeared identical with those of the *Glomerella* from other hosts.

On December 13 three plates were poured, using ascospores from the flask culture just described. On December 19 all the plates showed perithecia and also conidia.

On January 4 other plates were poured from the same material apparently containing ascospores only. Conidia developed in a few days, and perithecia also appeared later.

On January 23 subcultures were made in flasks of corn meal. On February 9 an abundance of perithecia and mature asci were present. Very few conidia were found. The fungus used in all these cultures appeared to belong to a race in which the perithecial form predominated. So far as known, no organism belonging to this group has heretofore been described or reported from the ginkgo. Plate II, figures 27 and 27a, shows an ascus and ascospores from leaves of this host.

GLEDITSIA TRIACANTHOS L. (HONEY LOCUST).

Glomerella cingulata (Stonem.) S. and v. S.

On November 24 cultures in flasks of corn meal were made by transferring conidia from an acervulus on a leaf taken from a locust tree on the grounds of the Department of Agriculture. A little leaf tissue was also included in this transfer. On December 1 all of the cultures were identical in appearance and showed an abundant growth of young perithecia of *Glomerella* with asci but no fully mature ascospores. No acervuli or conidia were seen. On December 9 there was an abundance of mature perithecia and ascospores present. No distinct acervuli or conidia were positively identified in these cultures, though the cultures were derived from conidia or conidia-bearing mycelium from the leaf of the host. On January 4 poured plates were made, using ascospores from the flask cultures just mentioned. These ascospores germinated readily and produced a growth of the usual appearance. On January 8 conidia were found in these cultures. On January 10 two more plates were poured, using ascospores from the same cultures. These spores germinated, and on January 15 perithecia were found at many points in the plates. This strain also showed a great predominance of perithecia. In other respects it appeared identical with the *Glomerella* from other hosts. An ascus and ascospores from cultures from this host are shown in Plate II, figures 20 and 20a.

GOSSYPIUM HIRSUTUM L. (COTTON).

Glomerella gossypii Edge.*Colletotrichum gossypii* South.

DEVELOPMENT ON BOLLS AND STEMS IN MOIST CHAMBER.

On February 20 leafless tips of cotton stems received from Lome, Togoland, western Africa, were treated as usual and placed in sterile moist chamber. These specimens showed dried whitish patches, suggesting old acervuli of *Colletotrichum gossypii*, but no conidia could be found. On February 23 acervuli with the characteristic brown setae of this species were present on the stems. Transfers from these acervuli to flasks of corn meal produced an abundant growth of conidia and a dark mycelium but no perithecia.

On May 7 eight apparently healthy bolls about three-fourths grown were taken from a single plant in the greenhouse. The surface was sterilized as usual and the bolls placed in a moist chamber. On May 22 these bolls were more or less discolored, but no fungus was visible. On May 25 one of the largest bolls was almost completely covered with acervuli of *Colletotrichum gossypii*. On June 17 four other bolls also showed acervuli. As these bolls had been in the same chamber with the other, it is possible that infection came from the first boll.

On June 22 five other bolls of various ages were treated in the same way, but no *Colletotrichum* developed on any of them. These experiments would appear to indicate that the fungus on the cotton is able to live in a dormant or hibernating condition, as has been found to be the case with most of the other forms.

CULTURES.

On October 28, 1905, sections from a diseased cotton boll were transferred to flasks of corn meal. These all developed a growth resembling that of the cotton anthracnose, and on November 23 one flask showed acervuli with pink masses of conidia and also perithecia with ascospores not quite mature. All the other flasks showed a luxuriant growth of a white mycelium and conidia. Transfers were made from a flask producing perithecia. These also produced perithecia and ascospores.

Tests were also made of the effect of corrosive-sublimate solution, 1 to 1,000, on conidia of this fungus, the spores being treated from five to seven minutes and then transferred to poured plates. Check plates were made at the same time to determine the vitality of the spores. The checks grew luxuriantly, but no growth appeared in the plates sown with spores treated with corrosive sublimate, indicating that they had all been killed.

The appearance of this fungus in cultures is quite characteristic and remarkably uniform. The mycelium usually becomes dark colored rather early in its growth and the acervuli quite constantly produce an abundance of setæ which occasionally bear conidia, evidently indicating the derivation of the setæ from ordinary conidio-phores. The production of the perithecial form of this fungus was first reported by the writers (75) in 1907 from the cultures described above. Later, Edgerton (29), 1909, reported finding the perithecial form on cotton bolls in Louisiana and named the fungus *Glomerella gossypii*. Since this fungus appears to possess certain morphological characters both under natural conditions and in cultures sufficient to separate it from its near relatives, it is apparently deserving of specific rank. Cross-inoculation experiments also seem to sustain this conclusion. An ascus and ascospores are shown in Plate I, figures 12 and 12a.

HEDYSCEPE SP. (PALM)

Glomerella cingulata (Stonem.) S. and v. S.

Acervuli and perithecia with ascospores agreeing in all essential particulars with those of *Glomerella* as it occurs on other hosts were found on leaves of this host in the Department greenhouse. No pure cultures were obtained of this form. An ascus and ascospores from this material are shown in Plate II, figures 26 and 26a.

LIGUSTRUM VULGARE L. (PRIVET).

Glomerella cingulata (Stonem.) S. and v. S.

Gloeosporium cingulatum Atk.

DEVELOPMENT ON LEAVES AND STEMS IN MOIST CHAMBER.

Diseased leaves and stems of privet sent from Digby, Nova Scotia, and received September 30, showed fertile perithecia agreeing with the description of *Glomerella cingulata* except that the measurements of the ascospores were slightly less than those given by Stoneman (89). A single acervulus bearing conidia of the usual form and also showing a few setæ was also found on a sunken light-brown spot on one stem. This twig and others showing dark swollen points suggesting immature acervuli or perithecia were placed in a sterile moist chamber.

On October 4 mature perithecia had developed on this material and ascospores were oozing from the ostioles in light pinkish masses. Conidia developed a little later on the leaves and stems also. Perithecia also developed on the leaves in moist chamber.

CULTURES.

On October 16 plates were poured, using conidia from a leaf in the moist chamber. On October 24 many dark acervuli were present, the color being due in part to the dark basal hyphæ and in part to the brown setæ. On November 6 many mature perithecia were also found in the plates. Subcultures made by transfer of conidia from these plates also developed perithecia. Several other cultures made from the same material produced both acervuli with setæ and mature perithecia with ascospores. In some of the cultures the perithecial form predominated.

In order to study the behavior of the fungus with reference to its variability in different generations under practically the same conditions, a pure line or strain was isolated by taking single conidia from a plate which had also produced ascospores. These were transferred to tubes of corn-meal agar. The plates from which they were taken finally developed acervuli with setæ; also some perithecia. Only one of the tubes containing a single conidium gave a pure culture; the others became contaminated. This one produced several rather definite areas of mature perithecia and a few acervuli bearing pinkish masses of conidia. The second generation was obtained by transfers of conidia from this tube to two others. One of these tubes produced an abundance of perithecia, while the other contained fewer perithecia and a greater development of mycelium. Conidia were present in both, but were few and did not form in large, distinct acervuli. These cultures had the same general appearance as the first generations from ascospores described below.

On October 18 pure-line cultures were started, using a single ascospore from a poured plate made from ascospores derived from the original twigs. This culture developed a rather scanty growth of light-colored mycelium with but few conidia. Later, a few perithecia were found, but asci had not developed. The culture became contaminated with bacteria and was discarded.

One tube, to which a whole ascus had been transferred, produced a few inconspicuous acervuli with setæ and later an abundance of perithecia with mature asci and spores. Transfers were made from this tube, producing the second ascospore generation. A few conidia developed but no distinct acervuli. Mature perithecia and ascospores were also formed. The perithecia were not evenly distributed, as was sometimes the case in other cultures, especially those from the form on *Persea gratissima*.

Generation 3 was started by transfer of perithecia from generation 2. This culture produced an abundance of perithecia and a few conidia without acervuli. The appearance of the cultures was very similar to that of generation 2.

For generation 4, six transfers were made of perithecia from generation 3. These soon developed numerous small acervuli with setæ. Few perithecia formed in these cultures. Other cultures made at the same time from ascospores from another series from this host made a growth of quite different appearance, no acervuli and very few conidia being formed. Few perithecia appeared. A further discussion of the pedigreed cultures will be given later.

Five transfers of single conidia were made from a plate subculture originally from a single ascospore culture. The growth produced in the five tubes was identical in appearance. A few acervuli developed near the point of inoculation and concentric rings of perithecia extended to the base of the culture. No asci were produced, however, so far as could be found. Plates poured from conidia from one of these tubes developed an abundance of conidia, but no distinct acervuli were formed. Chlamydospores and perithecia were present, but, as in the preceding generation, no asci developed.

The spores of this form, both ascospores and conidia, were very variable in size. The conidia in cultures ranged from 12 to 33 by 4.5 to 7 μ . On the host they ranged from 12 to 21 by 4.5 to 6 μ . Ascospores from the host ranged from 13.5 to 23 by 4.5 to 5.5 μ . Ascospores from cultures varied from 16.5 to 24 by 5 to 6 μ .

Miss Stoneman (89) gives the ascospore measurements of this species as 20 to 28 by 5 to 7 μ , which still further extends their range of variation. Unless the study of a vast number of spores from various localities should establish a constant mean spore measurement decidedly different from that found in *Glomerella* from other hosts, there seems to be no way of distinguishing this plant specifically from it. An ascus and ascospores are shown in Plate II, figures 17 and 17a.

MALUS SYLVESTRIS MILL (APPLE).

Glomerella cingulata (Stonem.) S. and v. S.

Glomerella rufomaculans (Berk.) S. and v. S.

Gloeosporium fructigenum Berk.

Several attempts were made to develop this fungus from twigs of the 1-year-old growth taken from trees which had been badly affected with bitter-rot. In the 12 trials made no *Gloeosporium* was obtained in the cultures.

The production of the perithecial form from this host has already been described by several writers, both on the host and in pure cultures. It is therefore unnecessary to give a detailed account of our work on this point. Fertile perithecia of *Glomerella* are often produced on apples which have been attacked by bitter-rot; and they are also frequently obtained in cultures, though their production can not be depended upon in any particular strain. Here, as in forms from

other hosts, there appear to be fertile and sterile strains so far as the production of ascospores is concerned. Fertile perithecia have been produced in flasks of corn meal by transplanting portions of an apple taken from just beneath the skin where ascogenous perithecia were formed, and subcultures from these have continued to produce perithecia.

Leaves from trees badly affected with bitter-rot produced acervuli of *Glomerella* in abundance when kept in a sterile moist chamber. From this host, as from others, a strain of the fungus is sometimes obtained which produces peritheciump-like bodies in which no ascospores develop.

CULTURES.

Fifteen tube cultures, made September 14, using conidia from acervuli on different bitter-rot spots on a Willow Twig apple from Vienna, Va., all developed perithecia but no acervuli. In five of the tubes the perithecia were fertile, producing asci and ascospores. The other 10 produced only immature or sterile perithecia. Apples inoculated with ascospores from these cultures developed bitter-rot, followed by the production of fertile perithecia but no acervuli, indicating in this strain the great predominance of the perithecial form. Cultures made from apple leaves from West Virginia, obtained from Mr. Rand, produced perithecia with asci somewhat smaller than usual, as shown in Plate III, figure 39. Cultures of this form grown on sterile apple twigs also showed a few brownish ascospores.

The spore measurements of *Glomerella* as found on this host and in cultures are as follows: Asci from fruit in moist chamber 69 to 78 by 6 to 10.5 μ , in cultures 54 to 110 by 7.5 to 13 μ ; ascospores from apple 15 to 21 by 4.5 to 6 μ ; ascospores in cultures 13.5 to 21 by 4.5 to 6 μ . Variations in the asci from this host are shown in Plate III, figures 35 to 39. Plate I, figures 3 and 3a, also shows an ascus and ascospores of the same.

CHROMOGENIC FORM.

On November 16 four plates of corn-meal agar were poured from a single acervulus of *Glomerella* from an apple from Vienna, Va., which had been kept in moist chamber in the laboratory. These cultures produced an abundance of acervuli and chlamydospores. In the dilute plates the acervuli were numerous; in the thickly sown plates acervuli were almost entirely wanting and the conidia scattered. These cultures when about a week old began to take on a pinkish color, the color apparently being developed in the agar and not in the mycelium of the fungus. Four tubes inoculated by transfer of spores from four different acervuli from this same plate were made to determine whether this chromogenic character was possessed by other acervuli and whether it persisted. Four days later a slight pinkish

tinge was visible in all the cultures, and at the end of a week the agar had become a decided pink color, and acervuli were present in all the tubes.

On November 24 three more plates and three tubes were made from an acervulus on the same apple used in the previous cultures. From the poured plates six transfers of single germinated conidia were made to tubes.

On November 28 three cultures made by direct transfer from an acervulus on the same apple showed the same pink color observed in all previous cultures from this apple. Acervuli were present. There was no color in the plates at this time, though acervuli were present.

On November 30 the pink color was very conspicuous in the six single-spore cultures, and the cultures were practically identical in appearance with those in the other tubes. The appearance of the pink color in all the pure single-spore cultures completely dispelled the natural suspicion that the first cultures might have been contaminated. These cultures, though kept for several months, never developed any dark mycelium, the growth of hyphæ being white or only slightly grayish. The cultures differed in this respect from most other cultures from apples and other hosts, which usually produce more or less of a dark greenish or smoky-colored mycelium, especially when old. Chlamydospores were present in these cultures, but differed slightly from the usual form, many being large and regular. In the following June transfers were made from these old cultures, which were still living, to slant agar tubes. The growth was very slow. On September 4 conidia were present, and the agar showed a slight pinkish color. One tube showed little or no color. Other transfers from a tube showing color made a more abundant growth of acervuli and showed more of the pinkish color.

On December 4 two sound apples were inoculated by puncture, using conidia from one of the single-spore cultures from this chromogenic form. The surface of the apples was carefully sterilized by washing as usual, after which they were placed in a sterile moist chamber. Decay began at the points of inoculation in a few days, and on December 17 the decayed areas on both of the apples were more than an inch in diameter and slight pustules, apparently young acervuli, were developing on the skin. On December 26 acervuli having all the characteristics of *Glomerella* were numerous on the decayed spots. The conidia were extremely variable. No setæ were found.

On January 4 and 5 plates were poured, using conidia from one of the inoculated apples just described. Four transfers were made of single germinating spores to tubes of agar. The general appearance and development of the fungus in these tubes was very similar to that in the previous cultures of this chromogenic form. One culture failed to grow; the other three soon began to show the pink color in the

medium. The color in these cultures never became quite so pronounced as in some others.

On January 6 six tube cultures were made by transfer of conidia from a single acervulus in one of the single-spore cultures just described. Three were on prune agar and three on a synthetic medium. The cultures on prune agar made rapid growth, produced an abundance of acervuli, and the medium became a decided pink color. No perithecia or perithecialike bodies ever appeared in any of these cultures. The constant white or grayish color of the mycelium, the chromogenic character of the fungus, and the variation in the conidia suggested very strongly the possibility that we were dealing with an organism different from the common bitter-rot fungus of the apple. The conidia were very variable in size. Those which were scattered were rather smaller than usual, and those borne in the acervuli were large and more uniformly pointed at the ends. As no perithecial form was found on the fruit from which the cultures were obtained nor in any of the cultures, it is possible that this may represent a distinct species or variety.

EUROPEAN FORM.

Schneider-Orelli (69) has recently reported the results of comparative studies of the conidial stage of *Glomerella cingulata* sent from Virginia and *Gloeosporium fructiginum* Berk. found on apples in Switzerland. He finds very little difference in the morphological characters of the American and European forms. A comparison of their physiological characteristics showed a difference of 5 degrees centigrade for minimum, maximum, and optimum growth. The minimum temperature at which growth occurred in the European material was 5°, the optimum temperature 23°, and the maximum temperature 27° C., while the minimum, optimum, and maximum for the American material was found to be 5 degrees higher, or 10°, 27°, and 32° C., respectively. Whether this difference would hold good with other races and strains from the two countries is a question. The writers have carried out no such comparative studies but have reason to suspect that further work in this direction might show that this physiological character is also variable in both the American and European forms. Little difference was found in the production of rot caused in stored apples when inoculated with the two forms. According to the writer just cited, as well as other European pathologists, the bitter-rot fungus is not common in Europe and where present causes very little loss. It seems probable that this is due, in great part at least, to the less favorable climatic conditions prevailing in parts of Europe where apples are mostly grown, the low average maximum summer temperature being perhaps the chief factor as compared with the average summer temperatures in the parts of the United States where the dis-

ease is most serious. As has been pointed out elsewhere in this paper, there is evidence to show considerable difference in the virility of different strains of the fungus from different sources in this country, and this fact may explain the difference in destructiveness of the disease in localities where climatic conditions are apparently equally favorable and the disease is present.

MANGIFERA SP. (MANGO).

Glomerella cingulata (Stonem.) S. and v. S.

On May 6 leaves and stems of mango received from Hallandale, Fla., showing acervuli of *Gloeosporium*, were placed in a moist chamber. On May 18 perithecia with immature asci and numerous acervuli were found on the leaves, and many acervuli were also present on the stems. In the absence of mature ascospores there is a possibility that the perithecial form associated with the conidia was not *Glomerella*, but this is not probable.

On May 29 plates were poured, using conidia from the mango leaves in moist chambers, and later, single germinating conidia were transferred to tubes. These cultures produced an abundance of large acervuli with pink spore masses, and a few setæ were found. The general characters of the growth were as in the forms from other hosts, though the mycelium varied somewhat in quantity and color. No perithecia ever occurred in these cultures, though immature perithecia developed on the leaves from which the cultures were made. The conidia from a single acervulus in one of these cultures varied from 12 to 25.5 by 3.5 to 6 μ .

Three species of *Gloeosporium* have been described from the mango, *G. mangae* Noack (61), *G. mangiferae* Henn. (46), and *G. raciborski* Henn. So far as the descriptions go they can not be satisfactorily separated. The extremes in the spore measurements given for these three species are nearly all included within the range of the measurements found in the single acervulus just referred to, while setæ were present in some acervuli and wanting in others.

MARANTA ARUNDINACEA L. (ARROWROOT).

Glomerella cingulata (Stonem.) S. and v. S.

On January 29 a portion of a leaf of this species, showing a small dead area, was taken from a greenhouse plant, treated as usual, and placed in a sterile moist chamber. On February 7 acervuli had developed, and a little later immature perithecia were found. Tube cultures were made by transfer of conidia from the leaf just described. These cultures produced a growth of the usual appearance of *Glomerella*. Numerous acervuli with pinkish masses of conidia were

formed. Though the cultures were kept for nearly a year, no perithecia were ever found in them. The fungus agreed in all essential particulars with *Glomerella cingulata*.

MUSA PARADISIACA SAPIENTUM (L.) KUNTZ. (BANANA).

Gloeosporium musarum Cke. and Mass.

Cultures of this fungus, which is frequently found upon decaying bananas, have been made at different times. The growth and appearance of the fungus in cultures in most cases is somewhat different from that of the other forms grown. A slight amount of white mycelium generally appears at first and soon becomes dotted with small, dark bodies which suggest perithecia, but when carefully examined they prove to be small acervuli. The acervuli usually develop in great numbers and, being crowded, produce large continuous masses of salmon-pink spores. Chlamydospores were very abundant in some cultures. No setæ were ever found. A few dark perithecium-like bodies were occasionally found in old cultures, but no asci or spores ever developed.

Spore measurements obtained from conidia in a single acervulus in a culture were 9 to 28 by 4.5 to 6.5 μ . In other cultures conidia were found reaching 34 μ in length and 8.5 μ in thickness. With no knowledge of the perithecial stage of this form, it is not possible to make any positive statements in regard to its identity with the species of *Glomerella* from other hosts. In some cultures it showed essentially the same characters and appearance as in the forms from other hosts, while in others, as mentioned above, it showed rather different characters.

Most of the attempts to transfer the *Gloeosporium* on banana to other fruits have been failures. Laubert (56) had no success in inoculations from the banana to apples, though Cobb (21) reports success in producing bitter-rot of pears and quinces with the banana fungus.

OXYCOCOCCUS MACROCARPUS (AIT.) PERS. (CRANBERRY).

Glomerella cingulata vaccinii Shear.

This fungus has been found at various times on both fruit and foliage of the cranberry and has already been reported on by the senior writer (74). More recently the perithecial form has been again obtained in a number of cases from fruit collected in Massachusetts. Cross-inoculation experiments with apples have given negative or uncertain results. In one case a small decayed spot appeared, and a few acervuli formed. It is possible that this variety would adapt itself to another host in a few generations as some of the other forms have done.

PERSEA GRATISSIMA GAERTN. F. (AVOCADO).

Glomerella cingulata (Stonem.) S. and v. S.

DEVELOPMENT ON LEAVES IN MOIST CHAMBER.

On January 15 apparently healthy leaves from a greenhouse plant with the surfaces sterilized as usual were placed in a sterile moist chamber. Dark spots soon appeared on these leaves, and on February 3 an abundance of acervuli with pinkish masses of conidia were present. No perithecia were found.

On July 1 other leaves of normal appearance from the greenhouse were treated in the same manner as the preceding. On July 26 numerous acervuli were present and also perithecia with immature asci. Later, mature asci and spores were found.

On December 30 leaves showing small dead areas were taken from the same source and treated in the same manner as above. On January 7 abundant acervuli with setæ were found on one of the leaves. On January 17 a few mature perithecia were found on the same leaf. They were characterized by unusually long beaks. Later, acervuli and perithecia developed on the other leaf also.

CULTURES.

On December 18 five plates were poured, using conidia from a single acervulus on avocado fruit received from Miami, Fla. A few setæ were present in this acervulus. Three single germinating conidia were transferred to tubes. On January 5 both plates and tubes differed in appearance from the earlier cultures from *Persea*, especially in the scarcity, or almost complete absence, of conidia. A few dark stromatic bodies were present in the plates, but no perithecia. A very few acervuli finally developed in the tubes, but no setæ or perithecia were found.

On January 6 plates were poured, using conidia from acervuli which had developed upon an apple inoculated with conidia from the same avocado fruit. A loose white growth of mycelium was produced, bearing very few conidia. These cultures differed conspicuously from plates poured at the same time, using conidia from the avocado fruit. The growth was much more abundant in the latter case and the conidia more numerous, suggesting the possibility that the fungus had lost some of its vitality through its development on the apple. A few setæ were found later and a few apparently immature perithecia finally developed.

On January 6 more plates were poured, using conidia from the same avocado fruit. A luxuriant white growth soon developed, producing an abundance of conidia but no distinct acervuli. Transfers to tubes from these plates produced acervuli with an abundance of setæ and a few apparently immature or sterile perithecia.

On April 30 other plates were poured, using conidia from a leaf taken from a plant in the greenhouse. Germinating conidia were transferred from one of these plates to two tubes. On May 15 both the tubes and the plate showed acervuli with pinkish masses of conidia, and a number of areas of fertile but immature perithecia were found in the plate. The conidia were much more abundant in the tubes than in the plates. Later, a few fertile perithecia developed in the tubes. Transfers of conidia from these tubes to flasks of corn meal grew rapidly and in about a week perithecia formed, but no conidia could be found. A little later the perithecia matured and gave an abundance of ascospores. Plates poured, using these ascospores, produced few conidia and no distinct acervuli, but numerous chlamydospores and an abundance of fertile perithecia.

Many other transfers from this material, both of conidia and ascospores, showed considerable variation in the appearance of the growth and the relative development of conidia and perithecia. Perithecia usually predominated in the plates, whether started from conidia or ascospores. Conidia were more frequently scattered and hyphomycetous than in distinct acervuli. Various attempts were made to determine whether the amount of culture medium used in the plates or the thinness and thickness of the sowing of the spores had any direct relation to the production of ascospores or perithecia. In the case of a strain of the fungus which normally produced perithecia it appeared that perithecia were more numerous and conidia less so in plates which were thickly sown. In about a dozen cases perithecia were found forming along the sides of cotton fibers which happened to be present in the agar. This suggested that the resistance of some solid substance might possibly stimulate their formation. In many cases, especially in this form from *Persea*, the perithecia showed a tendency to develop about an acervulus, forming a small cluster or group, with the acervulus as a stromatic base.

Two series of generations of pure-line cultures were started from the same original culture of this organism. In one case ascospores only were used and in the other case conidia only. The ascospore cultures were carried through seven generations on the same medium and under practically the same conditions of growth and environment. The conidial cultures were carried through 23 generations and their behavior was compared with the generations from ascospores, as well as with duplicate cultures of each generation. An account of these cultures will be given later under the head of "Pedigreed cultures."

The conidia from leaves in moist chamber varied from 11 to 19.5 by 4.5 to 5.5 μ . Conidia from cultures varied from 12 to 18 by 4.5 to 6 μ . Ascospores from leaves averaged about 18 by 6 μ . Those in cultures ranged from 13.5 to 22.5 by 4.5 to 6 μ . An ascus and ascospores are shown in Plate I, figures 10 and 10a. Bessey (12)

and Rolfs (66) have referred the conidial form of the fungus on avocado to *Colletotrichum gloeosporioides* and Bessey (12) reports successful cross-inoculations from citrus fruits and mangos, thus confirming its identity physiologically as well as morphologically with the organism on the orange, which in turn can not be satisfactorily separated from the form on privet, apple, etc. According to the authors cited, infection takes place through the flowers. Higgins (47) has recently described a serious disease of avocado in Hawaii which he considers as probably due to *Gloeosporium*. Its effect upon the plant, attacking as it does flowers, foliage, and shoots, is the same as that of the organism just described.

PHASEOLUS VULGARIS L. (WAX BEAN).

Glomerella lindemuthianum Shear. n. comb.

Colletotrichum lindemuthianum Sacc. and Magn.

Numerous cultures of the bean anthracnose have been made at different times and in different seasons. The cultures from conidia in most cases have been rather uniform in appearance and behavior, agreeing with the descriptions given by Atkinson (3), Whetzel (95), Edgerton (30), and others. In 16 slant agar tubes made November 3 from different acervuli on 5 bean pods the growth soon became very dark colored. This appears to be quite a constant characteristic of this species, and all the cultures made were practically identical in appearance during their growth. No perithecia were produced in these cultures.

The acervuli varied greatly in number and size in different cultures, and setæ, though usually present, were not numerous. Many chlamydospores were also found in some cultures. Cultures from single conidia, showing the usual appearance of the fungus, are shown in Plate VII.

In December cultures were made in flasks of corn meal by transfer of conidia and a bit of tissue from a bean pod bearing acervuli of the bean-anthracnose fungus. Later, all of the flasks showed good perithecia and asci, but conidia were scarce or wanting. An ascus and ascospores are shown in Plate I, figures 13 and 13a. These cultures finally became contaminated and were discarded. Plates were previously made from them, using the crushed perithecia and asci. The ascospores germinated readily and produced a dense growth of mycelium of the usual appearance. No conidia were found in these plates. Other plates poured from the same ascospore material produced the same typical mycelial growth; and at the end of 12 days perithecia were present in great numbers, but no conidia were found. Other plates were poured on March 16. A single ascospore transferred to a tube and afterwards to a flask of corn meal produced the

usual growth of mycelium; and on April 3 an abundance of perithecia with mature asci were present, but no conidia were seen.

This is the only case in the writers' experience with these organisms in which cultures made from ascospores have apparently produced no conidia or if they were formed they were so few in number that they escaped observation. It does not appear, however, that there can be any doubt about these perithecia belonging to the bean anthracnose. The cultures were originally started from the conidial form on a bean pod and conidia were found in the first cultures with the perithecia. The perithecia, asci, and all the morphological characters of the fungus agree with *Glomerella*, as will be observed by comparing Plate I, figures 13 and 13a, and also the measurements of conidia and ascospores. The fact that conidia were few in the original culture and wanting in others apparently shows only an extreme variation in this particular, as cultures from different hosts have shown a great degree of variability in respect to the relative abundance of the different spore forms in any race or strain, and there seems to be a general tendency on the part of cultures from ascospores to produce fewer conidia than do those which originate from conidia. In the case of the form from the gooseberry (*Ribes oxycanthoides*), described later, the predominance of perithecia was also very striking. Conidia, though present, were usually scattered or formed minute acervuli which were very inconspicuous and easily overlooked, whereas the perithecia were produced in great numbers and were very conspicuous.

In one other series of cultures from conidia from a bean a few small peritheciump-like bodies were found at the edge of the culture, but no asci or ascospores were obtained.

The appearance and behavior of this organism in cultures, as well as the failure of cross-inoculation experiments, apparently shows it to possess sufficiently well-marked characteristics to justify its separation as a distinct species, though the perithecial form taken alone could be distinguished with great difficulty, if at all, from that obtained from other hosts. It is tentatively named *Glomerella lindemuthianum* Shear.

PHORMIUM TENAX FORST.

Glomerella cingulata (Stonem.) S. and v. S.

?*Physalospora phormi* Schröt.

On April 1 slant agar tubes were inoculated by transfer of spores from an acervulus of *Gloeosporium* on a leaf of *Phormium* from the greenhouse. The growth in these tubes had the same general appearance as that of most other forms of this species grown from other hosts. A few acervuli formed with pinkish masses of conidia. Peritheciump-like bodies were numerous in the cultures, but no asci could

be found. Transfers to flasks of corn meal made from one of the above tubes passed through the same course of development and produced peritheciump-like bodies. A few apparently immature asci were found in some of these, but though kept about two months no ascospores were ever seen. Other subcultures from this same series continued to produce conidia and the dark peritheciump-like bodies, but no mature asci were ever discovered. Chlamydospores of the usual kind were present in great abundance in some of the cultures.

Physalospora phormi Schröt. (72) as described from this host agrees with *Glomerella* and is presumably the perithecial form of the *Gloeosporium* from which our cultures were made. The conidia varied from 9 to 15 by 4.5 to 5 μ .

Gloeosporium phomiforme Sacc. and Ell. also described from this host is apparently a different organism, as the conidia are said to range from 5 to 6 by 3 to 3.5 μ . There seems little doubt that the species grown by the writers should be referred to *Glomerella cingulata* (Stonem.) S. and v. S., though no mature asci were seen.

PIMENTA ACRIS (SWARTZ) KOSTEL. (WILD CLOVE).

?*Glomerella cingulata* (Stonem.) S. and v. S.

On January 19 leaves with small dead areas were taken from a greenhouse plant, the surface sterilized as usual, and placed in a moist chamber. Acervuli of the usual character of *Gloeosporium* soon developed on the leaves, and later a few immature perithecia with asci were found, but the spores were not sufficiently developed for positive identification.

Cultures made from the conidia on these leaves produced a growth of the usual character. Conidia were formed, but no acervuli appeared until the cultures were nearly 3 weeks old. No setæ were found. Peritheciump-like bodies developed in the thickest sown plates, but no ascospores were seen. The conidia ranged from 11 to 17 by 4 to 6 μ . No fungus of this kind appears to have been reported on this host heretofore.

PIPER MACROPHYLLUM SWARTZ (PEPPERWORT).

?*Glomerella cingulata* (Stonem.) S. and v. S.

On January 30 apparently normal, healthy leaves taken from a greenhouse plant, after sterilization of the surfaces as usual, were placed in a moist chamber. The leaves soon became discolored, and on February 7 numerous acervuli were present. No perithecia were ever found on these leaves.

Slant agar tube cultures were made, using conidia from the leaves in moist chamber. The growth was of the usual appearance of *Glomerella* cultures, and scattered acervuli with pink masses of conidia

appeared. On March 10 about 25 perithecia of different sizes had developed in one tube. These contained immature asci. Subcultures made from this tube showed the same characters as the first, except that numerous setæ were present in the acervuli. These cultures produced many perithecia, but no mature asci could be found. This seems to be the first report of the occurrence of such a fungus on this host.

PITCAIRNIA CORALLINA LINDEN.

Glomerella cingulata (Stonem.) S. and v. S.

On January 29 normal, apparently healthy leaves were taken from a greenhouse plant and after the usual treatment placed in a sterile moist chamber. The leaves soon became covered with dark blotches, and a few scattered acervuli developed. No setæ were found. On February 25 fertile perithecia of *Glomerella* were abundant on both sides of the leaf. No paraphyses were seen. The asci and spores were apparently identical with those from various other hosts. An ascus and ascospores are shown in Plate II, figures 25 and 25a.

Plate and tube cultures made from conidia on the leaves in moist chamber produced a growth of the usual appearance of *Glomerella* cultures. Acervuli soon appeared. Setæ were abundant in some of these cultures, whereas the original tubes showed no setæ. Chlamydospores also developed and in two corn-meal flasks peritheciump-like bodies occurred, but no asci were found. The conidia from the leaves in moist chamber varied from 12 to 18 by 5 to 6 μ ; ascospores from the leaves measured 15 to 18 by 4.5 to 6 μ .

The host indexes mention no organism of this kind on this host.

PSIDIUM GUAJAVA L. (GUAVA).

Glomerella cingulata (Stonem.) S. and v. S.

Glomerella psidii (Del.) Sheldon.

Sheldon (78, 80) has already described the life history of this form. The work of the present writers covers the study of the development of the fungus on leaves in moist chamber and in pure cultures.

DEVELOPMENT ON LEAVES IN MOIST CHAMBER.

On January 29 five apparently healthy leaves were taken from a tree in the greenhouse and after the usual treatment placed in a sterile moist chamber. The leaves soon showed dark blotches and finally became entirely discolored. Acervuli developed first on the petiole and later occurred scattered over the upper and lower surfaces of the leaves. They appeared less numerous and more irregularly distributed than in the form produced on citrus leaves in moist chamber. On April 8 a few perithecia were found on these leaves.

On April 30 two small young leaves in whose axils no flower buds were located, also two leaves a year old in whose axils fruit had been borne, were treated as usual and placed in moist chamber. On May 16 acervuli were abundant on the old leaves, but none were present on the new leaves. Though kept until June 22 no acervuli or perithecia developed on the young leaves, while acervuli and perithecia were numerous on the older leaves. This would suggest the possibility of the fungus having entered the old leaves by way of the flowers of the previous season, while the flowers in the axils of the new leaves not having opened, the new leaves had not yet become infected.

One leaf, in the axil of which fruit had just set, did not develop any *Gloeosporium* in moist chamber nor did another which bore a flower in its axil.

Four terminal leaves from different shoots situated 1 to 4 inches beyond any fruit and four leaves at the base of fruits, were placed in moist chamber. One leaf in each set developed acervuli. These last experiments do not seem to indicate any clear connection between flowers and fruit and infected leaves in this case. It seems more probable that the dormant infections came from local infection of the leaves.

CULTURES.

Numerous cultures started from conidia from leaves placed in moist chamber at different times during the year, produced a mycelial growth of the usual general appearance of *Glomerella*. Acervuli were formed in all the cultures, but usually they were not numerous. The spore masses were pink. No setæ were found in any of the cultures. Chlamydospores occurred in some. Perithecia were never found in the cultures.

Cultures made from conidia from fruit of guava in the greenhouse had the same general appearance as those from leaves. Setæ appeared, frequently in great abundance, in nearly all the cultures derived from fruit. Chlamydospores were also abundant in some of these cultures, but no perithecia were found. The conidia from the host ranged from 13.5 to 19.5 by 4.5 to 6 μ . Conidia from cultures varied from 13.5 to 18 by 4.5 to 6 μ . Ascospores from the host ranged from 13.5 to 21 by 5.5 to 6 μ . An ascus and ascospores are shown in Plate I, figures 9 and 9a.

There is nothing, so far as could be determined, in the morphological characters or behavior of this fungus in cultures or on its host to distinguish it from *Glomerella cingulata* as it occurs on citrus fruits and other evergreen-leaved plants as well as pomaceous fruits. Inoculation experiments reported by Cobb (21) indicated that the fungus could be successfully inoculated into apple, banana, pear, and quince. The form on apple was also successfully transferred to guava by the same investigator.

RIBES OXYACANTHOIDES (GOOSEBERRY).

Glomerella cingulata (Stonem.) S. and v. S.*Gloeosporium ribicolum* Ell. and Ev.

On July 5 decaying gooseberries were found at Arlington Farm, Va. Some of these berries showed acervuli of *Gloeosporium ribicolum* Ell. and Ev. and others developed acervuli when placed in a moist chamber.

Test tube cultures were made by transferring conidia from these berries. The growth in the tubes was of the usual appearance of *Glomerella* cultures. On July 14 acervuli were present in three of the four tubes. They were few in number and located about the point of inoculation. The development of the mycelium was rather more scanty than usual and showed little indication of the dark color which frequently develops in old cultures. These cultures never developed more acervuli, but small groups of perithecia appeared which were either sterile or immature. Transfers were made from each of these tubes to four others. These cultures developed very few acervuli and conidia. Two of these cultures developed distinct stromatic masses of perithecia, all fertile and producing typical ascospores. The massing of the perithecia in these two cultures was very conspicuous, as the perithecia of *Glomerella* are most frequently either scattered or but slightly aggregated.

Apples were inoculated with ascospores from these cultures, as described later, and the cultures made from the tissues of these decayed apples produced large quantities of perithecia but very few and minute acervuli. The conidia developed were mostly scattered. Plates poured from the cultures from the inoculated apple had a very characteristic appearance. The perithecia developed in great numbers and were quite evenly distributed throughout the medium instead of being aggregated in masses. Acervuli developed on the surface of the medium at certain points, but they were very small and inconspicuous. The perithecia appeared to be rather larger and thicker walled than usual in *Glomerella*, but the asci and spores as well as conidia agreed in all respects with those from other hosts. The passing of one generation of the fungus through the apple had apparently increased its vitality in some way, as it grew much more luxuriantly in the cultures made from the apple and developed perithecia and conidia much more abundantly.

RUBUS OCCIDENTALIS L. (BLACK RASPBERRY).

Glomerella cingulata (Stonem.) S. and v. S.*Glomerella rubicola* (Stonem.) S. and v. S.*Gloeosporium rubi* E. and E.

Diseased canes of black raspberry received from Shelbyville, Tenn., were placed in a moist chamber. The diseased areas soon produced typical acervuli with dark-colored setæ. Later many perithecia of *Glomerella* also appeared on the canes.

On March 29 the surface of some of the diseased canes was disinfected as usual, and pieces of the discolored inner bark and wood were transferred to flasks of sterile corn meal. These cultures produced a growth of white mycelium but no acervuli. On April 17 perithecia of *Glomerella* were present with mature asci and ascospores apparently identical with those found on the canes in the moist chamber.

Other cultures made from conidia on the same canes in the moist chamber produced conidia but no distinct acervuli. Fertile perithecia developed in large numbers over the entire surface of these cultures. Other cultures from the same source and also subcultures continued to produce fertile perithecia in abundance, but conidia were always few and no distinct acervuli were found. Subcultures made from ascospores also produced an abundance of fertile perithecia, but no conidia were found. Chlamydospores also occurred in these cultures. The conidia found ranged from 10.5 to 18 by 5 to 6.5 μ . Ascospores averaged about 15 by 6 μ .

The perithecial stage of this form was first produced in culture by Stoneman (89). Several species of *Physalospora* and of *Laestadia* have been described from *Rubus* which do not differ essentially from this *Glomerella*, so far as the descriptions go. There seems to be no way of separating this fungus from *Glomerella cingulata*. In the absence of inoculation experiments showing that it will not pass to the apple or other hosts it is referred to that species.

RUBUS TRIVIALIS MICHX. (WHITE DEWBERRY).

Gloeosporium rufomaculans (Berk.) Thüm.*Gloeosporium rubi* E. and E.

Early in May, 1909, specimens of white dewberries were received from Macon, Ga. The fruit was soft and had a water-soaked appearance, suggesting a fungous disease. After washing the berries thoroughly in corrosive sublimate, cultures were made on corn meal by transferring portions of the pulp from the berries. One of the flasks to which pulp was transferred, developed a pure growth of *Gloeosporium* of the usual appearance. The acervuli were numerous and produced pinkish masses of conidia. No perithecia developed in

these cultures. Other specimens of the same diseased dewberries kept in moist chamber also produced acervuli. Poured plates were made with conidia from these acervuli. Acervuli but no setæ were found in the cultures, and no perithecia were produced. The conidia varied in size from 9 to 16 by 4.5 to 6 μ . In one set of these cultures the conidia averaged rather smaller than in the others, being mostly 9 to 13.5 by 4.5 μ . This form does not appear to be distinct from that just described from the black raspberry, though the material used in these cultures produced no perithecia. Inoculation experiments described later show that this form adapts itself quickly to the apple.

SMILAX MEDICA SCHL. AND CHAM.

Gloeosporium rufomaculans (Berk.) Thüm.

On October 31 acervuli of a *Gloeosporium* were found on leaves of this *Smilax* in the greenhouse of the Department of Agriculture. Plates which were poured from this material produced a growth of mycelium of the usual character and an abundance of conidia but no distinct acervuli. Transfers were made from these plates to tubes which soon produced large acervuli with pinkish masses of conidia. Later, the mycelium became dark colored, but no perithecia were ever found and no setæ were seen. The conidia ranged from 10.5 to 19.5 by 5 to 6 μ . The fungus as it appeared on the host and in cultures showed no characters to distinguish it from the conidial forms of *Glomerella* found on most of the other hosts studied. No species of *Gloeosporium* or *Glomerella* seems to have been reported heretofore on *Smilax*.

THEA JAPONICA (L.) BAILL. (CAMELLIA).

Glomerella cingulata (Stonem.) S. and v. S.

Colletotrichum camelliae Mass.

DEVELOPMENT ON LEAVES IN MOIST CHAMBER.

On January 29 apparently normal, healthy leaves were taken from a greenhouse plant, the surfaces sterilized as usual, and the leaves placed in a sterile moist chamber. They soon began to show a dark discoloration extending from the petiole up the midrib almost to the tip and finally became entirely discolored. Acervuli occurred on all the leaves, and fertile perithecia of *Glomerella* were also present but not abundant.

CULTURES.

Tube cultures were made, using conidia from the acervuli on the leaves in moist chamber, as described above. These cultures produced abundant acervuli but no perithecia. No setæ occurred, though setæ were abundant in the acervuli on the leaf. In other

cultures from the same leaves acervuli and chlamydospores were found, but no perithecia.

In February leaves of camellia, showing acervuli of *Gloeosporium*, were received from South Carolina. Cultures were made from the conidia on these leaves. The fungus developed in the usual manner, but produced very few conidia and no distinct acervuli. The mycelium later became dark colored, and finally two perithecial forms were found; one appeared to be *Glomerella*, while the other produced large brown septate ascospores, indicating that the culture was impure. The *Glomerella*, however, was apparently identical with that on the leaves and presumably originated from the conidia used. The conidia on the host ranged from 13.5 to 18 by 4.5 to 6 μ . Setæ were rarely found. The ascospores from perithecia on different leaves varied greatly. On one leaf they ranged from 10.5 to 18 by 6 μ and were only slightly curved or inequilateral. On another leaf they were more distinctly curved and ranged from 15 to 28.5 by 4.5 to 9 μ . (See Pl. I, figs. 15 and 15a.) Though the ascospores in this case appear to show a greater range of variation than in some other cases, still there appears to be no good basis for separating this form from that on the orange.

THEA SINENSIS L. (TEA).

Glomerella cingulata (Stonem.) S. and v. S.

Laetadia camelliae (Cke.) Berl. and Vogl.

Colletotrichum camelliae Mass.

DEVELOPMENT ON LEAVES IN MOIST CHAMBER.

On December 4 leaves with small dead areas were taken from tea plants in the greenhouse and placed in a sterile moist chamber. Acervuli with setæ and perithecia of *Glomerella* soon appeared on the leaves and many mature asci were found. No paraphyses were seen. An ascus and ascospores are shown in Plate II, figures 16 and 16a.

On April 29 other leaves showing small discolored areas were placed in moist chamber. Acervuli of *Glomerella* with pink masses of conidia soon appeared on these, and 10 days later an abundance of mature perithecia were found. These perithecia in most cases showed rather distinct but inconspicuous beaks. Paraphyses were also found in these.

Attempts made in February and May to obtain the fungus from apparently healthy tea leaves placed in moist chamber were unsuccessful.

CULTURES.

Two cultures on sterile corn meal, made by transfer of conidia from a tea leaf in a moist chamber, produced a few conidia but no distinct

acervuli. Mature perithecia of *Glomerella* were found in both these cultures in about three weeks. Chlamydospores were also present.

On July 5 a tube culture was started from a single conidium. This developed the usual growth and produced acervuli. Two subcultures were made in flasks of corn meal. These cultures started about as usual and were identical in appearance, but the mycelium began to assume a bluish smoky color rather sooner than in most cases. Acervuli with pinkish masses of conidia also developed. These cultures were kept for nearly a year, but no perithecia were ever found. The conidia on the leaves in moist chamber ranged from 15 to 21 by 4.5 to 6.5 μ .

Several species of *Gloeosporium* and *Colletotrichum* have been described as occurring on tea. They all appear to belong to this *Glomerella* except *Gloeosporium theae-sinensis* Miyake which has conidia only 4 to 6 by 2 μ . The conidial form might be referred either to *Gloeosporium* or *Colletotrichum*, as setae were found on leaves in moist chamber but not in cultures. A microscopic study of the type specimen of Masee's (58) species, *Colletotrichum camelliae*, leaves no doubt of its identity with the conidial form of the fungus just described.

THEOBROMA CACAO L. (CHOCOLATE NUT).

Glomerella cingulata (Stonem.) S. and v. S.

Colletotrichum theobromicola Delacr.

On January 19 leaves of cacao or chocolate nut showing small dead areas but no fungus fructifications were taken from greenhouse plants, the surfaces sterilized as usual, and placed in a moist chamber. Many acervuli of *Colletotrichum* soon appeared, especially along the midrib. Setae were abundant and also immature perithecia, which later (March 10) showed an abundance of mature asci and ascospores. Paraphyses were also seen. An ascus and ascopores are shown in Plate II, figures 24 and 24a.

Plate cultures were made, using conidia from the leaves in moist chamber just described. Transfers were made from these plates to four tubes in which a growth of whitish mycelium of the usual character developed and soon large acervuli with pinkish masses of conidia appeared at the point of planting in two of the tubes. In the other two no distinct acervuli were found. Setae were more frequently present on the host than in the cultures. In some of the poured plates no setae were found. In one tube where setae were abundant one was found bearing a spore, as sometimes happens in the species occurring on cotton. No perithecia were ever found in any of these pure cultures, and no ascogenous fungus has been described from this host, so far as noted, which seems to agree with the

Glomerella which appeared on the leaves. The conidia from the leaves ranged from 15 to 18 by 6 μ and agreed in all respects with *Colletotrichum theobromicolum* Delacr. (26). Two or three other species of *Colletotrichum* have been described from this host. The conidial measurements given are smaller than those of our organism, and they may perhaps belong to different species. Bancroft (5) has discussed the species on this host.

VANILLA PLANIFOLIA ANDREWS (VANILLA).

Gloeosporium rufomaculans (Berk.) Thüm.

On January 26 plates were poured, using conidia from acervuli on leaves of vanilla received from Miami, Fla. Setæ were present in some of the acervuli and wanting in others. Acervuli soon developed in the poured plates, and four subcultures were made in tubes. Acervuli soon developed in the tubes, but their number, size, and distribution varied greatly. In one tube there was only one large acervulus, in another the surface of the medium was thickly dotted with acervuli with pinkish spore masses. In some of the tubes the mycelium remained whitish, in others it became quite dark colored. The variations in amount and color of the mycelium, and in the number, size, and distribution of the acervuli were very striking. No perithecia or peritheciump-like bodies were found in any of these cultures. The conidia from the leaves ranged from 13.5 to 24 by 4.5 to 6 μ .

There are no sufficient morphological characters to distinguish this fungus from that found on the grape and apple. It has therefore been referred to the same species. *Physalospora vanillae* A. Zimm. (97) is apparently the perithecial form.

VITIS LABRUSCA L. (CONCORD GRAPE).

Glomerella cingulata (Stonem.) S. and v. S.

Gloeosporium rufomaculans (Berk.) Thüm.

On July 30 plates were poured from acervuli of *Gloeosporium* found on rotten grapes at Washington, D. C. These produced the usual whitish mycelium and numerous acervuli, and a little later perithecia of *Glomerella* with mature asci and spores were found. Transfers of perithecia from these plates to tubes produced large acervuli and a considerable growth of the dark bluish hyphæ which frequently characterize old cultures. Mature asci and perithecia were found in one of these tubes. In two others perithecia were present but no asci were seen.

On September 25 four plates were poured, using conidia from a single acervulus in the tube just described, which contained the fertile perithecia. Transfers were made from these plates to four other

tubes. Acervuli developed in abundance in tubes *a* and *b*. The mycelium was white and rather scanty. In tubes *c* and *d* the mycelium was much more abundant and darker colored. Chlamydospores were also found in these cultures. On October 16 many perithecia were present in tube *a* but none in *b*. The difference between these two tubes was striking, though the cultures came originally from the same acervulus. Variations in the size and shape of the asci are shown in Plate III, figures 30 to 34.

In two cultures out of eight made in August from diseased tissue on small black sunken spots on shoots of a Concord grapevine from Vienna, Va., both acervuli and perithecia of *Glomerella* were produced. Setæ were found in these acervuli. As other organisms predominated in most of the cultures, it is, of course, uncertain whether any of these cankers were primarily due to *Glomerella*, which has not heretofore been reported as occurring upon grape shoots, so far as known. Setæ seemed to occur less frequently in the form from the grape and apple than in those from other hosts. Other cultures from grapes from different parts of Virginia produced an abundance of acervuli, and also in one case numerous peritheciump-like or sclerotoid bodies, which always remained sterile. The asci ranged from 55 to 98.5 by 9 to 15 μ . Asci and ascospores are shown in Plate I, figures 1, 1a, 2, and 2a.

The perithecial form seems to be the *Physalospora baccae* of Cavara (17). The conidial form has been described by the same author as *Gloeosporium physalosporae*.

MISCELLANEOUS.

In order to compare the behavior of *Glomerella* from different hosts in pure cultures, tubes were inoculated February 7 with conidia from leaves of the following six hosts which were growing in the greenhouse: *Caryota*, *Costus*, *Curculigo*, *Maranta*, *Persea*, and *Piper*. These cultures all made a growth practically identical in appearance, and most of the tubes produced acervuli varying more or less in number and size. The mycelial growth was about equal in all. One tube from *Costus* and one from *Curculigo* failed to produce acervuli. The difference in these cultures from different hosts was much less marked than is frequently the case in cultures made from a single acervulus on the same host.

On January 29 apparently healthy leaves were taken from nine different hosts in the greenhouse, as follows: *Citrus limonum*, *Citrus decumana*, *Citrus nobilis*, *Eriobotrya japonica*, *Psidium guajava*, *Thea japonica*, *Pitcairnia corallina*, and *Ficus longifolia*. The surfaces were thoroughly washed with corrosive sublimate, 1 to 500, and the leaves then placed in sterile moist chambers. On February 15 all the

leaves had developed acervuli of *Glomerella* and some showed perithecia as well.

From these and numerous other experiments of a similar kind performed at different times during the year with leaves from other plants, it appears that this fungus is quite generally present in the leaves of many plants in a dormant or innocuous condition awaiting some weakening of the host or other favorable condition which may give it an opportunity to develop.

PEDIGREE CULTURES OF *GLOMERELLA* CINGULATA FROM AVOCADO.

The characters compared in the pure-line cultures were chiefly the relative abundance and particular characteristics of the conidial and perithecial fructifications. These were all perithecium-producing strains at the start. In some cultures conidia predominated and but few perithecia occurred; in others conidia were few and perithecia predominated. In some the conidia were scattered and hyphomycetous, while in others they were produced in distinct acervuli, frequently large. The perithecia were sometimes separate and scattered evenly and thickly over the surface of the medium; in other instances they were aggregated in dense masses.

The arrangement of the perithecia, whether separate or aggregated in a stroma, has usually been regarded by mycologists as important and has been used as the basis for separating genera and families. All the cultures were grown on the same medium (corn-meal agar) in a culture room under ordinary room temperature and conditions.

FIRST SERIES OF SEVEN GENERATIONS STARTED FROM A SINGLE ASCOSPORE.

Generations 1 and 2 were very similar in appearance. They produced conidia and an abundance of perithecia evenly scattered over the surface of the medium, as shown in tube 2a, Plate VIII. Generation 1 also showed some submerged perithecia.

The third generation was very similar to the first two but showed more of the deeply submerged perithecia.

In the fourth generation the perithecia, instead of being scattered evenly over the surface, as in the three previous generations, were compacted in black masses, giving the cultures a very different appearance from the earlier generations.

Generations 5, 6, and 7 showed the same characters as generation 4. The variation in arrangement and grouping of the perithecia seems to have been transmitted from generation 4 through these three generations. This series was discontinued at this point. In this case an important variation or mutation suddenly occurred in the fourth generation and was transmitted through three following generations.

CONIDIAL GENERATIONS FROM THE SAME HOST.

Generation 1 was started from a single conidium taken from a culture which also produced fertile perithecia. Acervuli and conidia were abundant at first in these cultures and a few perithecia formed in the lower part of the tubes.

Generations 2, 3, and 4 varied but slightly in general appearance and relative abundance of acervuli and perithecia from generation 1.

Generation 5 was practically the same as generation 4.

Generations 6 and 7, consisting of three tubes each, showed acervuli in abundance and lines of submerged perithecia developed in the medium as in some of the ascospore cultures, but they were much fewer.

Generation 8 showed an apparent reversion to the condition of the first five generations, with the same general distribution, arrangement, and relative number of acervuli and perithecia.

Generation 9 was strikingly different from generation 8. Acervuli were few and the perithecia very numerous and thickly scattered over the surface of the medium, resembling most of the ascospore generations. Tube 9a is shown in Plate IX. Two plates poured from this tube showing the same predominance of perithecia are illustrated in Plate XIV.

Generation 10 showed an apparent reversion again to the form in the first five generations. Acervuli were abundant and large; the perithecia were fewer and mostly grouped about the acervuli.

Generation 11, tube *b*, was practically identical in appearance with generation 10, tube *b*. Acervuli and perithecia were numerous. Generation 11, tube *c*, was very strikingly different from generation 10, tube *c*, showing large acervuli and masses of conidia, but very few perithecia.

Generation 12, consisting of tubes *b* and *c*, did not show the characters of the previous generation but rather the reverse, perithecia being abundant and acervuli few.

Generation 13 produced abundant acervuli, but the perithecia were much fewer than in generation 12. The two tubes *b* and *c* are shown in Plate VIII.

Tubes *b* and *c* of generation 14, derived from generation 13, tubes *b* and *c*, respectively, were strikingly different. Tube *b* produced almost entirely conidia with scattered acervuli, while *c* consisted almost entirely of perithecia formed along the line of inoculation. These tubes are shown in Plate VIII.

Tubes *b* and *c*, generation 15, were very similar to tubes *b* of generations 13 and 14. A few perithecia were present in each, but they were not numerous and predominating, as in tube *c* of generation 14.

Of generation 16, tubes *b* and *c* scarcely differed from 15. Acervuli and perithecia were present in both. They are shown in Plate IX. Seven subcultures from tube 16 *b* showed rather regular intergradations from tube 1, which contained perithecia chiefly, to tube 7, which contained chiefly acervuli. These subcultures are shown in Plate X.

Tubes *b* and *c* of generation 17 were strikingly and remarkably different. Tube *b* produced perithecia in abundance, covering the surface of the medium as in most ascospore generations. A very few small acervuli were present. Tube *c* showed an abundance of large acervuli and a very few scattered perithecia. These two cultures are shown in Plate IX, together with their parent cultures 16 *b* and 16 *c*.

Of 4 subcultures of conidia, numbered 17 *d*, *e*, *f*, and *g*, from culture 16 *b*, three showed perithecia predominating like 17 *b*, and one had acervuli predominating as in the original 16 *b*. (See Pl. XII.) Eight more subcultures made from tube 16 *b* gave four with perithecia like tube 17 *b* and four of an intermediate character, acervuli and perithecia both being present. Six other subcultures from tube 16 *b* resembled the parent culture. None of them showed a continuous layer of perithecia as in tube 17 *b*. Nine subcultures made from conidia from tube 16 *c* were all very similar in appearance throughout their growth. Acervuli were first produced as in the parent tube, but an abundance of perithecia later appeared. They were aggregated in masses in marked contrast to those in cultures from tube 16 *b*. Seven of these tubes are shown in Plate XIII. Out of 8 transfers from culture 17 *b*, which, as mentioned above, produced perithecia covering almost the entire surface of the medium, 7 were almost identical in appearance, showing a great predominance of acervuli and few perithecia, while only one resembled the parent culture. Tube 17 *b* with 6 of these subcultures is shown in Plate XI.

Tubes *b* and *c* of generation 18 grown from tubes 17 *b* and *c*, respectively, were very different in appearance. Acervuli predominated in culture *b* and perithecia in culture *c*, just the opposite of the parent cultures.

Tubes *b* and *c* of generation 19 were about like the ordinary conidial cultures. Acervuli and perithecia were both present, but acervuli predominated. Tube 19 *b* is shown in Plate XII.

Generation 20 *b*, from tube 19 *b*, produced both conidia and perithecia, but the latter were more abundant and covered a broad area on both sides of the culture, as illustrated in Plate XII.

Generations 21, 22, and 23 were all very much like the ordinary conidial cultures in which acervuli predominated and were most conspicuous, although some perithecia were always produced.

These variations might perhaps be regarded as renewed expression of latent hereditary characters or as mutations. If mutations, we

should rather expect them to be transmitted more or less regularly, but they appear for one or a few generations and then disappear without any particular regularity or definite sequence. This behavior would appear to put them in the category of fluctuating variations, which are not supposed to be transmitted. The media and the conditions under which the cultures were grown were made as uniform as practicable in order to eliminate the influence of different factors of environment.

 OCCURRENCE OF SETÆ AND PERITHECIA IN *GLOMERELLA*.

 TABLE I.—Record of the writers' observations on the occurrence of setæ and perithecia in *Glomerella*.

Host.	Setæ.		Perithecia.		Miscellaneous.
	Cultures.	Host.	Cultures.	Host.	
<i>Annona cherimola</i> (cherimoya).	Present....	Not observed	.....	.....	
<i>Brya ebenus</i> (ebony).....	.....	do.....	.....	Present....	
<i>Caryota rumphiana</i>.....	.....	Sometimes present.	.....	do.....	
<i>Cinnamomum seylanicum</i> (cinnamon).	.....	Not observed	Present....	.....	
<i>Citrullus vulgaris</i> (watermelon).	Abundant....	do.....	.....	.....	
<i>Citrus aurantium sinensis</i> (sweet orange).	Sometimes present.	Sometimes present.	.....	Present....	
<i>Citrus decumana</i> (pomelo).	do.....	do.....	Present....	do.....	
<i>Citrus limonum</i> (lemon)...	do.....	do.....	.....	do.....	
<i>Citrus nobilis</i> (mandarin)...	Few seen, sometimes absent.	Present; not numerous.	.....	do.....	
<i>Coffea arabica</i> (coffee)....	.....	Sometimes present.	.....	do.....	
<i>Costus speciosus</i> (spiral flag).	Sometimes present.	Present; not numerous.	.....	do.....	
<i>Crataegus</i> sp. (hawthorn)...	.....	.....	.....	.....	
<i>Cucumis sativus</i> (cucumber).	Sometimes present.	.....	.....	.....	No pure cultures.
<i>Cucurbita pepo</i> (squash)...	.....	Sometimes present.	.....	.....	
<i>Curculigo</i>.....	.....	do.....	.....	Present....	
<i>Eriobotrya japonica</i> (loquat).	.....	do.....	.....	do.....	
<i>Ficus carica</i> (fig).....	Sometimes present.	.....	Present....	.....	Paraphyses present.
<i>Ficus elastica</i> (rubber plant).	do.....	.....	do.....	Present....	
<i>Ficus longifolia</i>.....	.....	Sometimes present.	.....	do.....	
<i>Ginkgo biloba</i>.....	.....	.....	Present....	.....	
<i>Gleditsia triacanthos</i> (honey locust).	.....	.....	do.....	.....	
<i>Gossypium hirsutum</i> (cotton).	Usually present.	Usually present.	do.....	.....	
<i>Hedyosme</i> (palm).....	.....	.....	.....	Present....	No cultures.
<i>Ligustrum vulgare</i> (privet).	Sometimes present.	Present; not numerous.	Present....	do.....	
<i>Malus sylvestris</i> (apple)...	.....	Sometimes present.	do.....	do.....	(¹)
<i>Mangifera</i> sp. (mango)....	Sometimes present.	.....	.....	Present; asci immature.	
<i>Maranta arundinacea</i>.....	.....	.....	.....	Present but immature.	
<i>Musa paradisica sapientum</i> (banana).	.....	.....	.....	.....	
<i>Oxyococcus macrocarpus</i> (cranberry).	Present....	.....	Present....	.....	
<i>Persea gratissima</i> (avocado).	Sometimes present.	Present on fruit.	do.....	Present....	
<i>Phaseolus vulgaris</i> (wax bean).	do.....	Present....	do.....	.....	

¹ A few brown ascospores in culture; chromogenic form found.

TABLE I.—*Record of the writers' observations on the occurrence of setae and perithecia in Glomerella—Continued.*

Host.	Setae.		Perithecia.		Miscellaneous.
	Cultures.	Host.	Cultures.	Host.	
<i>Phormium tenax</i>	Found only on cabbage leaf inoculated with this form.		Present; asexual immature.		
<i>Pimenta acris</i> (wild clove).....			Present but sterile.	Present but immature.	
<i>Piper macrophylla</i> (pepperwort).....	Sometimes present.		Present; asexual immature.		
<i>Pithecellobium corallina</i>	do.			Present.	
<i>Psidium guajava</i> (guava).....	Present; not numerous.	Abundant on fruit; rare on leaves.		Present on leaves.	
<i>Ribes oxycanthoides</i> (gooseberry).....			Present.		
<i>Rubus occidentalis</i> (black raspberry).....		Sometimes present.	do.	Present.	
<i>Rubus trivialis</i> (white dewberry).....					
<i>Smilax medica</i>					
<i>Thea japonica</i> (camellia).....		Sometimes present.	Doubtful; culture not pure.	Present.	
<i>Thea sinensis</i> (tea).....		do.	Present.	do.	(1)
<i>Theobroma cacao</i> (chocolate nut).....	Sometimes present.	do.		Paraphyses present.	(2)
<i>Vanilla planifolia</i> (vanilla).....		do.			
<i>Vitis labrusca</i> (Concord grape).....	Sometimes present.		Present.		

¹ Paraphyses present on leaves.² In one case a small spore was found attached to a seta.TABLE II.—*Hosts from which ascogenous perithecia of Glomerella as well as conidia have been reported either in cultures or on the host, or both.*

Host.	Perithecia.		Paraphyses.	Investigators.
	Cultures.	Host.		
<i>Anthurium warocqueanum</i>		Present.		Edgerton, 1908.
<i>Artocarpus incisa</i>		do.		Delacroix, 1908.
<i>Asclepias syriaca</i> (milkweed).....		do.		Edgerton, 1908.
<i>Brya ebeneus</i> (Jamaica ebony).....		do.		Shear and Wood.
<i>Capsicum annuum</i> (pepper).....	Present.			Stoneman, 1898.
<i>Caryota rumphiana</i>		Present.		Shear and Wood, 1909.
<i>Cattleya</i> sp.....		do.	Present.	Maublanc and Laenier, 1904.
<i>Cinnamomum zeylanicum</i> (cinnamon).....	Present.	Present.		Shear and Wood, 1909.
<i>Citrus aurantium</i> (sweet orange).....				Do.
<i>Citrus decumana</i> (pomelo).....	Present.	do.		Do.
<i>Citrus limonum</i> (lemon).....		do.		Do.
<i>Citrus nobilis</i> (mandarin).....		do.		Shear and Wood.
<i>Coelogyne cristata</i> (orchid).....		do.		Edgerton, 1909.
<i>Coffea arabica</i> (coffee).....	Present.	Present on leaves.		Edgerton, 1908.
Do.....		do.		Shear and Wood, 1909.
<i>Coelus speciosus</i> (spiral flag).....		do.		Do.
<i>Curculigo</i> sp.....		Present.		Do.
<i>Cydonia vulgaris</i> (quince).....	Present.	Present on leaves.		Edgerton, 1909.
<i>Dracaena</i>	do.	do.		
Do.....	do.	do.	Present.	Sheldon, 1907.
<i>Eriobotrya japonica</i> (loquat).....		Present.	do.	Edgerton, 1908.
<i>Ficus carica</i> (fig).....		Present on fruit.		Shear and Wood, 1909.
Do.....	Present.	do.		Edgerton, 1911.
Do.....	do.	do.		Shear and Wood.
<i>Ficus elastica</i> (rubber plant).....	do.	Present on leaves.		Shear and Wood, April, 1907.
Do.....	do.	do.		
Do.....	do.	do.		Koorders, November, 1907.
Do.....	do.	do.		Edgerton, 1908.

TABLE II.—*Hosts from which ascogenous perithecia of Glomerella as well as conidia have been reported either in cultures or on the host, or both—Continued.*

Host.	Perithecia.		Paraphyses.	Investigators.
	Cultures.	Host.		
<i>Ficus longifolia</i>		Present.....		Shear and Wood, 1909.
<i>Ginkgo biloba</i>	Present.....			Shear and Wood, 1907.
<i>Gleditsia triacanthos</i> (honey locust).....	do.....			Do.
<i>Gossypium hirsutum</i> (cotton).....	do.....			Do.
Do.....	do.....			Edgerton, 1908.
Do.....		Present on bolls.....	Present.....	Edgerton, 1909.
<i>Hedyoscepe</i> sp. (palm).....		Present.....		Shear and Wood, 1909.
<i>Ligustrum vulgare</i> (privet).....	Present.....	do.....		Stoneman, 1898.
Do.....	do.....	do.....		Shear and Wood, 1909.
<i>Malus sylvestris</i> (apple).....	do.....	On fruit.....		Clinton, 1902.
Do.....	do.....	On fruit and cankers.....		Von Schrenk and Spaulding, 1903.
Do.....	do.....	On fruit.....		Scott, 1906.
Do.....	do.....	do.....		Shear and Wood, 1907.
Do.....	do.....	do.....		Edgerton, 1908.
<i>Mangifera</i> sp. (mango).....		Present.....		Shear and Wood.
<i>Maranta arundinacea</i>		do.....		Shear and Wood, 1909.
<i>Maxillaria picta</i> (orchid).....	Present.....	Present on leaves.....		Stoneman, 1898.
Orchid.....		Present.....		Edgerton, 1908.
<i>Oxyococcus macrocarpus</i> (cranberry).....	Present.....			Shear and Wood, 1907.
<i>Persea gratissima</i> (avocado).....	do.....	Present.....		Shear and Wood, 1909.
<i>Phaseolus vulgaris</i> (wax bean).....	do.....			Shear and Wood, 1907.
<i>Phormium tenax</i>	do.....			Shear and Wood, 1909.
<i>Pimenta acris</i> (wild clove).....	Present; sterile.....	Present.....		Shear and Wood.
<i>Piper macrophylla</i> (peppercorn).....	Present.....			Shear and Wood, 1907.
<i>Pitcairnia corallina</i>		Present.....		Shear and Wood, 1909.
<i>Psidium guajava</i> (guava).....	Present.....	Present.....	Present.....	Sheldon, 1905.
Do.....				Shear and Wood, 1909.
<i>Ribes oxycanthoides</i> (gooseberry).....	Present.....			Shear and Wood.
<i>Rubus occidentalis</i> (black raspberry).....	do.....	Present.....		Shear and Wood, 1909.
<i>Rubus strigosus</i> (red raspberry).....	do.....			Stoneman, 1898.
<i>Sarracenia purpurea</i> (pitcher plant).....		Present on leaves.....		Edgerton, 1908.
<i>Thea japonica</i> (camellia).....	Doubtful.....	Present.....		Shear and Wood, 1909.
<i>Thea sinensis</i> (tea).....	Present.....	do.....		Do.
<i>Theobroma cacao</i> (chocolate nut).....		do.....		Shear and Wood.
<i>Vanilla</i> sp. (vanilla).....		do.....		Stoneman, 1898.
<i>Vitis labrusca</i> (Concord grape).....	Present.....			Shear, 1907.

VARIABILITY OF GLOMERELLA.

The extreme variability of races of *Glomerella* from the same host which is in some cases greater than that of forms from different hosts renders it exceedingly difficult to make a satisfactory classification of the forms. No character, either morphological or physiological, seems to be well fixed. The appearance of the mycelium in cultures on agar is usually rather uniform. The hyphæ are mostly submerged and white at first, forming a circular colony. After a short time the mycelium frequently becomes dark greenish or smoke colored, and occasionally a pink color develops, as was the case in the chromogenic form obtained from the apple (p. 39). The dark color of the cultures is sometimes due to colored hyphæ and at other times to the presence of the black perithecia or sclerotia and appressoria.

CONIDIA.

The conidia show exceeding variability in their manner of production and all their morphological characters. In some cultures they are borne separately on scattered sporophores, suggesting a very diffuse hyphomycete. All intergradations between this form and forms having very large, compact, and distinct acervuli occur. In one strain derived from the gooseberry, certain cultures produced an aerial growth and conidiophores more or less erect and clustered, suggesting in macroscopic appearance a *Verticillium*. Pure cultures from these conidia, however, produced the usual form with acervuli, which was followed by the development of perithecia and ascospores. In size, shape, and color the conidia are also very variable. They have been found to range from 10 to 42 by 3 to 9 μ from the same host. They are rarely or never distinctly curved. When scattered on a slide they usually appear colorless, but vary from a very pale-cream to a bright-salmon color in masses. Occasionally a few dark-colored conidia have been found.

SETÆ.

Setæ are frequently entirely wanting in some cultures while abundant in others from the same host. Some acervuli from one single-spore culture may show many setæ, others few, and still others none. The setæ also vary greatly in size, length, and septation. In two forms, those from cotton and *Theobroma*, they have been found bearing conidia.

APPRESSORIA, OR CHLAMYDOSPORES.

The appressoria, or chlamydospores, are also exceedingly variable in size and shape. As has been pointed out by Hasselbring (45) and others, their occurrence appears to bear some relation to lack of available nutriment and to contact with some hard surface.

In water drop cultures on glass slides they usually develop either from conidia or ascospores in 24 to 48 hours. (See figs. 2 and 3.)

A germinating chlamydospore is shown in figure 4.

YEAST AND OTHER FORMS.

Viala and Pacottet (92) have reported the occurrence of yeast forms of *Gloeosporium*. Yeast forms have never occurred in any of the writers' pure cultures. They have occasionally been found, but only in cultures made directly from fruit, in which cases they were evidently contaminations. The same authors also report the production of spermagonia and pycnidia in *Colletotrichum lindemuthianum*. No fructifications of this kind have ever been found by the writers in pure cultures of *Glomerella*. The writers have never seen the endospores described by Sheldon (79) and confirmed by Taubenhaus (91).

PERITHECIA.

Perithecia have been found to vary in abundance, size, shape, arrangement, and location with reference to the surface of the medium. They are generally globose or subglobose, though sometimes elongated or pear shaped. The beak when present is usually very short, though commonly the perithecia are merely papillate. In rare cases, however, they have been found with distinct elongated beaks similar to those illustrated by Stoneman (89). On the host plant they have always been found embedded in the tissues. In artificial cultures they are usually embedded but occasionally form erumpent, superficial masses. Sometimes they are evenly scattered and entirely separate, as shown in Plate XV; at other times they are aggregated and seated upon a more or less distinct stromatic base. Occasionally they are almost sterile or are represented by simple black, solid, sclerotoid bodies.

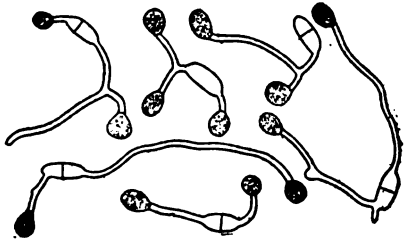


FIG. 2.—Germinating conidia of *Glomerella cingulata* from a culture from pear, showing the formation of chlamydospores after 24 hours in drop cultures of sterile water.

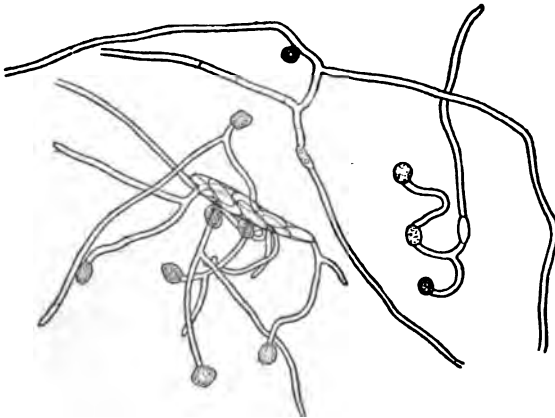


FIG. 3.—Germinating ascospores of *Glomerella cingulata* from cultures from gooseberry, showing formation of chlamydospores after 55 hours in drop cultures of sterile water. Ascospores usually produce longer germ tubes than conidia.

ASCI.

extremely variable in size and shape, as will be observed by a comparison of Plates I, II, and III and the measurements of specimens from the same and different hosts, as recorded in Table III. The apex of the ascus shows a peculiar structure which apparently has some relation to the expulsion of the spores. This feature has been discussed by Koorders (54).



FIG. 4.—A germinating chlamydospore, or appressorium, of *Glomerella cingulata* from a culture from gooseberry, showing the development of the germ tube after 24 hours in cornmeal agar.

ASCOSPORES.

The ascospores show almost as great variation in size, shape, and other characteristics as do the conidia. They range from 9 to 24 by 3 to 7.5 μ . The contents are sometimes rather coarse and granular, at other times more homogeneous. Vacuoles or oil drops are frequently present, sometimes one large one in the center or at each end, at other times two smaller ones at each end. Ascospores are almost always slightly curved. They are usually almost colorless, but when old and in mass they frequently show a pale-lemon or salmon color, and occasionally very old spores are decidedly dark colored.

PARAPHYSES.

The early investigators of *Glomerella* do not mention the presence of paraphyses. It will be seen, by consulting Table II that these bodies have not been very frequently found in our material or reported by others. When observed they appear to be very thin walled and are not always easily discerned. Their presence or absence does not seem to be sufficiently constant to be of much taxonomic value.

HOST RELATIONS.

Most of the forms from various hosts appear to be able to infect other hosts under certain conditions, at least, as indicated in Table IV, which gives the results of cross-inoculation experiments of other authors as well as of the writers. With a few exceptions, such as the bean and cotton anthracnose and perhaps the form from the squash, different races from the same host seem to vary as greatly in virility as do forms from different hosts.

CAUSES OF VARIATIONS.

In dealing with the phenomena of heredity and variation in *Glomerella* there is apparently no reason to believe that the Mendelian theory is involved or that heterozygosis takes place, as no union of nuclei between different individuals or species is known to occur. Edgerton (32) has recently expressed his belief in a cross-fertilization between two strains of *Glomerella* from *Populus*, but the evidence given is not conclusive.

It seems clear that whatever fusions may occur between nuclei in the development of the individual organism which arises from a single spore, such fusions, though they be admitted to represent sexual union, could scarcely be conceived to add or transmit any new characters to the resulting progeny unless they were characters acquired by one of the fusing nuclei and not by the other during the life history of the individual. It is difficult to conceive how the union of two

closely related nuclei originating in the same individual or the same cell could add to the essential characters of the organism in any way.

Individuals originating from single spores of *Glomerella* must be regarded as homozygous so far as it is possible to ascertain at present, i. e., no union of nuclei or gametes between different individuals, races, or strains has been proved.

Whatever differences the progeny of such individuals might show would evidently be due to mutation or some other internal cause, such as the renewed expression of latent hereditary characters, or else to some external or environmental action.

As it has been impossible to trace any causal relation or connection between most of the phenomena of variation observed and the conditions of environment to which the organisms were subjected, it must be concluded that the inducing causes are internal or else so obscure as to escape observation. In any case the evidence accumulated by others as well as by the writers appears sufficient to justify the conclusion that many of the variations observed and reported here are not entirely due to any effect of simple environmental factors. It must be remembered, however, that it is difficult if not impossible at present to standardize media and methods with sufficient accuracy to positively determine the exact effect of environmental factors on these fungi. Gorham (38) and others have pointed out the apparent impossibility of standardizing media containing agar and other organic compounds. Synthetic media of pure inorganic chemicals can not be substituted for many fungi, as they do not usually fruit on such media. More work is needed to verify the conclusions of Stevens and Hall (87) and others in regard to the direct effect of modifications of the chemical constituents of culture media on the behavior of parasitic fungi. The problem is evidently far more complex than some investigators have appreciated, and its complete solution can scarcely be hoped for in the near future, but the most hopeful line of attack seems to be that of pedigree cultures of asexual or unisexual organisms grown and observed under the most exactly determined and controlled conditions possible and in sufficiently large numbers and through enough generations to reduce probable errors from accidental causes to a minimum.

The work of Jennings (49) with *Paramecium* and that of Barber (6), Will (96), Beijerinck (11), and Hansen (44) on yeasts, as well as that of other authors cited by Pringsheim (65), demonstrate at least one thing, and that is the actual existence of rather distinct races or strains within species. These races possess more or less distinctive and constant morphological or physiological characteristics which are generally inherited by their progeny and are apparently not primarily dependent upon environmental conditions.

TABLE III.—*Measurements of conidia and ascospores from cultures and from the hosts, showing the ordinary range of variation.*

Host.	Conidia.		Ascospores.	
	Cultures.	Host.	Cultures.	Host.
<i>Annona cherimola</i> (cherimoya).....	12-16.5 by 4-4.5..	12-19.5 by 4-4.5..	"	"
<i>Brya ebenus</i>		12-19.5 by 4.5-5..		12-18 by 4.5-6.
<i>Caryota rumphiana</i>		13.5-25 by 4.5-6..		16.5-21 by 6.
<i>Cinnamomum seylanum</i> (cin- namon).....	10.5-12 by 3-4...	12-21 by 5-6..		
<i>Citrullus vulgaris</i> (watermelon).....	9-12 by 4.5-5...			
<i>Citrus aurantium sinensis</i> (sweet orange).....	10.5-18 by 3-4.5..	12-18 by 4.5-7.5..		12-18 by 4.5-6.
<i>Citrus decumana</i> (pomelo).....	14-17 by 4.5-7.5..	15-18 by 4.5-5..		18-28 by 4.5-6.
<i>Citrus limonum</i> (lemon).....	10.5-18 by 4-5...	12-18 by 4.5-6..		12.5-19.5 by 4.5-6.
<i>Citrus nobilis</i> (mandarin).....	11-19.5 by 4.5-6..	12-21 by 4.5-5..		16-19.5 by 4.5-6.
<i>Coffea arabica</i> (coffee).....	15-18.5 by 4.5-6..	13.5-16.5 by 5-6..		15-18 by 5-6.
<i>Costus speciosus</i> (spiral flag).....	10-16.5 by 4.5...	12-18 by 4.5-6..		15-21.5 by 5-6.
<i>Cucurbita pepo</i> (squash).....	8-30 by 3-4.5...	10-12.5 by 3-4..		
<i>Cucurbita</i> sp.....		14-16.5 by 4.5-5.75.		12-24 by 5.5-6.
<i>Eriobotrya japonica</i> (loquat).....		12-19 by 5-6..		
<i>Ficus carica</i> (fig).....	10.5-16.5 by 3.5-4.5.	12-15 by 4.5-5...	13.5-19.5 by 4.5-6	12-19 by 4.5.
<i>Ficus elastica</i> (rubber plant).....	10.5-22 by 4-6...	12-15 by 4.5-6...	13.5-24 by 5-6..	11-18 by 4-4.5.
<i>Ficus longifolia</i>	12-15 by 4-6...	16-20 by 6...		12-20 by 3-4.
<i>Ginkgo biloba</i>	10-22.5 by 4.5-6..	11-21 by 5-7.5...	11-21 by 4.5-6.5..	
<i>Gladiolus triacanthos</i> (honey locust).....		13.5-16.5 by 4.5-5..	12-24 by 5-7..	
<i>Gossypium hirsutum</i> (cotton).....	10-42 by 3-9...	12-25.5 by 4.5-6..	15-18 by 4.5-6...	12-19.5 by 4.5.
<i>Hedyoscepe</i> sp. (palm).....		12-14 by 4-5...		12-19.5 by 5-7.5.
<i>Ligustrum vulgare</i> (privet).....	12-36 by 6-7...	12-21 by 4.5-6..	13.5-23 by 4.5-6.5.	12.5-18 by 4.5.
<i>Malus sylvestris</i> (apple).....	12-18 by 4-4.5...	9-18 by 3-6...	12-19 by 4.5-6..	13.5-19 by 4.5-7.5.
<i>Mangifera</i> sp. (mango).....	12-25.5 by 3.5-6..	12-25.5 by 3.5-6..		
<i>Maranta arundinacea</i>		5-7.5 by 2-3..		
<i>Musa paradisica sapientum</i> (banana).....	9-28 by 3-6.5...	12-19.5 by 4.5-7.5..		
<i>Oxyccocus macrocarpus</i> (cran- berry).....	12-18 by 4.5-6...	10.5-21 by 4.5-6..	9-20 by 5-7.5...	
<i>Persea gratissima</i> (avocado).....	12-18 by 4-6...	12-18 by 4-5...	10.5-16.5 by 3-4.5	12.5-18 by 4.5-7.5.
<i>Phaseolus vulgaris</i> (wax bean).....	10.5-16.5 by 4.5-5..	12-16.5 by 4.5-6..	15-22.5 by 4.5-6..	
<i>Phormium tenax</i>	13.5-18 by 4-4.5..	12-19.5 by 4.5-6..		
<i>Pimenta acris</i> (wild clove).....	11-17 by 4-6...	10.5-15 by 4-5...		
<i>Piper macrophyllum</i> (pepper- wort).....	10.5-15 by 4-4.5..			
<i>Pithecellobium corallina</i>		13.5-18 by 4.5-5..		16.5-18 by 4.5.
<i>Psidium guajava</i> (guava).....	12-22.5 by 3-4.5..	12-19.5 by 4.5-5..		12.5-19.5 by 4.5-5.
<i>Ribes oxycanthoides</i> (goose- berry).....	13.5-18 by 4.5-6..		13.5-19.5 by 4-5..	
<i>Rubus occidentalis</i> (black rasp- berry).....		10.5-18 by 4-6.5..	13.5-19.5 by 4.5-5	15-18 by 4.5-6.
<i>Rubus trivialis</i> (white dew- berry).....	9-16 by 4.5-6....	12-22.5 by 3.5-6..		
<i>Smilax medica</i>	15-25.5 by 3-4...	12-19.5 by 4-5...		
<i>Thea japonica</i> (camellia).....		12-16 by 4.5-5...	12-19.5 by 4.5-6..	12-16.5 by 4-6.
<i>Thea sinensis</i> (tea).....	12-15 by 3.5-5...	15-18 by 4.5-6..		10.5-24 by 4-7.5.
<i>Theobroma cacao</i> (chocolate nut).....	10.5-13.5 by 4-4.5	13.5-18 by 4.5-6..		15-24 by 4.5-7.5.
<i>Vanilla planifolia</i> (vanilla).....		12-24 by 4-6...		
<i>Vitis labrusca</i> (Concord grape).....	10.5-20 by 4.5-6..	12-15 by 4.5...	12-21 by 4.5-8...	

NOTE.—The maximum and minimum measurements given could undoubtedly have been increased in many instances, as no special effort was made to determine the extremes in most cases.

THE PRODUCTION OF PERITHECIA IN GLOMERELLA.

The production of perithecia in *Glomerella* is a matter of considerable interest and importance, apparently involving some of the fundamental problems of evolution and development. Why is it that the full life cycle of this and various other pyrenomycetes is sometimes completed in pure cultures on sterile media, while at other times only conidia or pycnosporos or no fructifications of any kind

are formed? Various explanations and suggestions have been made by different writers at different times, but in most cases there has been no sufficient experimental evidence offered to establish fully any of the theories advanced. A brief review of the various attempts which have been made, and the suggestions offered, may be of some interest in this connection. Klebs (53), Smith (83), Brefeld (14), Stoneman (89), Appel and Wollenweber (1), Butler (16), Glück (37), Ihssen (48), and others have discussed the subject.

The production of the sexual fructifications of certain algæ and aquatic fungi may perhaps depend primarily upon factors of nutrition or environment which can be controlled under cultural conditions. The work of Klebs (53), especially, seems to justify such a conclusion. Much more work is necessary, however, to thoroughly verify this and especially to eliminate the possibility of some of the results being due to the use of different races or strains. Kauffmann (50) in the account of his studies on *Saprolegnia*, expressed the belief that their behavior depended entirely upon definite chemical and physical conditions readily controlled. He also thinks that culture media and conditions could be standardized and safely used as a basis for species segregation. This apparently needs further verification, as Lechmere (57) was unable to obtain the same results with these organisms.

In the case of the sexual forms of algæ some writers have attempted to show that there is a more or less regular periodicity in the appearance of the fertile fructifications of different species. Recent investigations by Danforth (22) appear to throw doubt upon the general application of this view also. However the case may be with the algæ, there is little or no evidence at present available to show that periodicity is an important factor in the production of the perithecial forms of *Glomerella* and other pyrenomycetes. In the writers' culture work with *Glomerella* and other genera, such as *Guignardia*, *Melanops*, and *Cryptosporella*, when mature spores are used, they have been unable to find any relation between the time of the collection or the age of the material and the production of the perithecial forms. Under natural conditions it is known that perithecia are in general most abundantly produced in temperate regions during late winter and spring.

Brefeld (14) suggested as the result of observations of ascogenous fructifications under natural conditions that their production depended to some extent on the season of the year and the substratum; but in our experience, cultures made from fresh material collected under natural conditions do not produce perithecia any more frequently from material collected at one time than at another. Various experiments in growing different strains of *Glomerella* and other pyrenomycetes on various substrata do not indicate that this

factor either determines the production of perithecia, though a fruiting strain will fruit more abundantly and freely on some substrata than on others.

It has also been suggested that the nearness or remoteness of origin from ascospores of conidia used in any particular series of cultures might be a factor of importance in determining the course of development of such cultures. The data bearing upon this question which we have obtained from our pedigreed pure-line cultures carried through several generations do not appear to support this theory, though perhaps the available data are not sufficiently numerous to justify definite conclusions.

Of a similar nature is the idea that the production of ascogenous forms occurs only at intervals after the virility or vitality of the conidial or pycnidial form has been greatly reduced by continuous asexual reproduction. There is no known evidence to support this view. Whether there is an actual or potential sexual stimulus or union of nuclei involved in the production of perithecia in *Glomerella* is not known. No work has been done on the cytological features of the development of the perithecia. As perfect fertile perithecia are produced in abundance in pure cultures from single spores, either conidia or ascospores, it seems certain that no fertilization or union of nuclei between different individuals is necessary. Whatever nuclear unions take place must be between nuclei of the same individual, as is known to be the case in some other ascomycetes.

The most general supposition has perhaps been that which predicated the production of perithecia as dependent upon certain conditions of nutriment or other environment of the organism. This has led to the trial, by most investigators, of various culture media of different constituents in different proportions and also the submission of cultures to various conditions of temperature, air, light, and moisture. Very little success with pyrenomycetous fungi has ever been attained in this direction. In no case have the writers been able to cause perithecia to appear in cultures which did not produce them when grown on corn-meal agar under ordinary laboratory conditions. So far as we have been able to determine, no cases have been reported in which the evidence was sufficiently conclusive to prove that perithecia were produced in artificial cultures as the direct result of modifications of the culture media. Smith (83) reports that the formation of perithecia in a fertile race of *Neocosmospora* was prevented by the use of strongly alkaline media, but no nonperithecia-forming strains were made to produce perithecia by change of medium.

Appel and Wollenweber (1), in discussing this problem as it relates to *Fusarium*, *Nectria*, *Neocosmospora*, etc., have made some very ingenious suggestions in attempting to account for the production or

nonproduction of perithecial forms in cultures. One is that the forms which produce perithecia in cultures on artificial culture media are pure saprophytes, whereas the forms which do not produce perithecia in cultures on artificial culture media are parasites which require the living host or living plant tissues to complete their development. This scarcely accords with the well-established fact that there are all grades and degrees of parasitism among fungi, from the highly specialized obligate forms, such as rusts and smuts, to the weak facultative forms which are only parasitic under certain conditions and in certain stages of their development and may be saprophytic under other conditions or in other stages. A large part of the pyrenomycetes, though parasites, are not of a high type. They frequently pass the early stages of their development—that is, their conidial and pycnidial conditions—as parasites on the living host, whereas they only complete their life history and produce their perithecial or sexual forms upon the dead tissues of the host after it has been killed either by the direct action of the fungus or by some other cause. This fact is emphasized by Masseo (59) in his discussion of the evolution of parasitism in fungi. It would not, therefore, appear remarkable if many of these forms should complete their life cycles on sterile culture media containing the essential nutrient substances required by the organism. There is apparently no reason to suppose that the case of *Fusarium* and *Nectria* is not directly comparable in this respect with that of *Gloeosporium* and *Glomerella*.

There seems to be an abundance of proof to establish the parasitic character of many forms of *Gloeosporium*. In case of the bitter-rot of the apple, for instance, this parasite has been obtained directly from the tissue of growing fruits before their maturity and when transplanted on artificial culture media has produced perithecia as well as conidia. Perithecia are also frequently produced upon fruits which have been destroyed by the parasite. The suggestion, therefore, that in cases where a *Fusarium* does not produce perithecia in culture media it is a parasite and that when a *Fusarium* does produce perithecia in culture media it is a saprophyte, does not appear to accord with what is already known in regard to *Glomerella* and some other pyrenomycetes.

The case of *Neocosmospora*, as described by Butler (16), is scarcely more conclusive. The fact that he did not succeed in infecting plants by the use of ascospores of *Neocosmospora* in the few attempts made does not necessarily prove that this fungus is not a parasite and that it is specifically distinct from the *Fusarium* form with which he made successful inoculations. As is well known to plant and animal pathologists, there is a great range of variability in the virility or capacity for infection of various races, strains, or forms of what are regarded as the same species; at least they must be so regarded

unless some other basis than morphological differences and differences in behavior in culture media can be established as a basis for species segregation. It should be shown either that there are morphological differences between the conidial form of the *Fusarium* causing the wilt and the conidial form of *Neocosmospora* sufficient to identify and separate them, or else a large series of inoculation experiments should be carried out, using ascospores and conidia from a variety of sources and including a sufficient number of strains to justify the conclusion that the fungus will not infect the host and may be considered a physiological species.

The other suggestion of the same authors is that the species of *Fusarium* with which they were working and which did not produce perithecia in cultures may be autonomous forms which have no perithecial stages and that their close resemblance to the conidial forms of *Nectria*, *Neocosmospora*, and related genera may be a mere superficial one which does not necessarily imply any direct relationship. This is ingenious also, but unfortunately it is incapable of experimental proof and is not in harmony with the present trend of mycological facts and opinions.

The connection between various conidial and pycnidial forms and their ascogenous stages is being slowly but surely proven by pure-culture methods, and it seems much more natural and reasonable to suppose that the majority at least of the so-called "imperfect fungi" are stages in the life history of ascomycetes and hymenomycetes, though comparatively few have yet been positively connected and the determining factors concerned in the complete development of the organisms are still unknown.

The production of perithecia in the numerous cases of *Glomerella* which are reported here is evidently a fairly well-fixed hereditary racial character. Having obtained by repeated cultures from different collections a race or strain which produces both conidia and perithecia on culture media, other generations grown from either the conidia or ascospores of this strain continue to produce both spore forms of the fungus indefinitely. In one case, *Glomerella cingulata* from *Persea*, as already described, a race was grown through 23 successive generations and still produced both conidia and ascospores in as great abundance as at first.

Miss Wakefield (93), as a result of her investigations of *Schizophyllum commune* and *Stereum purpureum*, finds also certain races which show a much greater tendency to produce spores than others under the same conditions of culture. Brefeld (14) states that *Penicillium* produces ascogenous fructifications at one time while at another, under exactly the same conditions, it produces only conidia.

All the writers' work with *Glomerella*, as well as with other pyrenomycetes, indicates that the production of perithecia is a hereditary

racial character which does not depend primarily on special conditions of nutriment or environment. This conclusion does not, unfortunately, bring us much nearer to the real cause of the phenomenon; it merely eliminates some of the factors heretofore regarded as controlling. The real nature of the inducing causes (for such must be supposed to exist) which determine whether a race shall produce ascogenous or only conidial fructifications is still unknown. Most frequently a strain producing fertile perithecia produces them in abundance. All sorts of intermediate conditions, however, occur from strains which produce only sterile peritheciump-like bodies or sclerotia to those which produce quite constantly great quantities of fertile perithecia. It is, of course, not certain that their behavior in nature corresponds in this respect to that under artificial conditions. Not all of the cultures started with conidia taken from acervuli which were associated with fertile perithecia on the same leaf produced perithecia. There is no certainty, however, that the acervuli and perithecia arose from the same strain, as the manner of the development of the fungus on leaves in moist chamber appears in many cases to indicate that there are more or less numerous points of dormant infection from which the fungus develops and the growth from these finally covers the whole leaf, as shown in Plate V. The intermingling of fructifications originating from different infections perhaps explains why no perithecia were produced in a number of cases in which cultures were made from leaves showing both acervuli and perithecia more or less mixed. No ascogenous strain has ever appeared in any of the hundreds of cultures of conidial strains which have been grown under various conditions on different substrata. Not having had an opportunity to observe the transition from a nonascogenous to an ascogenous race, any attempt to account for this change, which apparently must occur, would be purely hypothetical. The existence of certain intermediate conditions might suggest the gradual development of these ascogenous races, while the failure to produce any evidence that cultural or other environmental influences determine their production seems to indicate a deeper and more obscure cause for their origin. Ascogenous strains may perhaps arise as mutations. This suggestion, however, throws no light upon the cause of their origin.

It is possible that a knowledge of the nuclear phenomena occurring during the stages of development preceding ascus formation may throw some light upon this problem. The possibility of the existence of plus and minus strains uniting as in *Mucor* has been considered. In many cases where colonies originating from separate ascospores or conidia of perithecial strains meet in a plate culture there is a greater development of perithecia along the line of contact than in

other parts of the colonies (Pl. XV); but in no case have perithecia been produced under such conditions when the conidia belonged to a race of the fungus which did not produce perithecia in the separate colonies. Edgerton's (32) experiments along this line already referred to are not conclusive. That no such union of different strains is necessary or essential for the production of perithecia seems certain from the fact that perithecia develop in abundance in a colony derived from a single conidium or ascospore of a perithecial race. Until it has been demonstrated that the increase of perithecia at the point of contact between two colonies is due to nuclear fusions between the two growths it seems preferable to attribute the phenomenon to some simpler cause such as the greater exhaustion of the nutriment at the point or some other slight stimulus. For the present we must admit our utter ignorance of the determining factor or factors concerned in the production of ascogenous fructifications in *Glomerella*. Certain previously supposed factors, however, such as have already been discussed here, have in most cases been sufficiently tested to justify their elimination. This helps to simplify the problem somewhat and suggests research in other directions which may possibly prove more profitable.

INOCULATION EXPERIMENTS.

Inoculation experiments with *Glomerella*, either in the field or greenhouse, are not always conclusive. Under proper conditions and with plants known to be free from dormant infections, inoculations, by surface application of spores, under optimum conditions of temperature and moisture, should give the most trustworthy results. To be certain, however, that a plant is free from dormant infection, it must be grown from seed under conditions which would preclude the possibility of infection from any source except the inoculation.

Most of the inoculation experiments of the writers have, however, been made with fruits or plants growing under ordinary laboratory or greenhouse conditions. As it is a practical impossibility to determine whether any particular plant or part of a plant is entirely free from infection, under such conditions, the results obtained can not always be regarded as conclusive. In most of the experiments described here, inoculations were made by insertion of conidia or ascospores of *Glomerella* in the tissue of the host. Such experiments with immature fruits when made under proper conditions and with sufficient checks are believed to give evidence of some value in determining the host relationships of the organisms. In the case of perfectly mature fruits the significance may not be so great.

Since it has been found that different races or strains of *Glomerella* vary exceedingly in virility and also that different host plants and

varieties of the same host show great differences in susceptibility to any particular race of the fungus, it is clear that success or failure of inoculation experiments may depend, in many cases, on some of these factors. Further discussion of this subject will be found under the heading "Parasitism of Glomerella." Proper conditions of temperature and moisture are also necessary for successful infection either by surface application or puncture. Negative results from inoculation experiments with spores applied to the uninjured surface of a host can not be regarded in all cases as sufficient evidence that the plant is not susceptible to the disease, as the infection may really occur but not develop further at the time for lack of proper temperature, moisture, or host conditions.

In the inoculation experiments in which fruit was used, it was, in most cases, nearly or quite mature. The specimens were always thoroughly washed with corrosive sublimate, 1 to 500, to destroy any spores which might be present on the surface. They were then rinsed with distilled, or sterile, water, and placed in a sterile chamber. A small beaker of water was also placed in the chamber to afford a slight amount of moisture. Unless otherwise stated, the fruit inoculations were always made on picked fruit with a sterilized needle, conidia or ascospores being inserted in a small puncture through the skin. Checks were used which remained free from rot in all cases except where some special statement is made to the contrary.

APPLE TO APPLE.

Various inoculations of apples were made at different times by the writers, conidia of *Glomerella* from different races or strains being used, in order to compare the rapidity of their development and the effect upon the host. In all the cases in which the inoculations were made by punctures, infection occurred and decay followed. The fruit had the usual appearance of bitter-rot, and acervuli were usually produced. The spots developed to about 1 centimeter in diameter in a week. In some cases development was slower than when inoculations were made with conidia from other host plants.

In three series of experiments conidia were applied to the unbroken skin of nearly mature apples. In none of these cases did any rot follow, although the fruit was kept in a moist chamber for a long period.

Sound apples were inoculated by puncture, using conidia from a single spore culture of the chromogenic form of the apple *Glomerella*, which has already been described on page 39. Rot developed about each puncture with about the same rapidity as in other cases and acervuli were produced in about three weeks.

Clinton (19) reports successful inoculations of green fruit on trees by inserting conidia in punctures, as indicated in Table IV. He also

reports in the same place successful inoculations with ascospores inserted in punctures, and he succeeded in infecting green fruit picked from the trees by placing conidia in drops of water on the unpunctured skin. In two experiments, however, no infection followed spraying the spores on the surface of green fruit. In one experiment he reports successful infection by applying ascospores to the unbroken surface in a drop of water.

Von Schrenk and Spaulding (70) report the successful inoculation of apple limbs by the introduction of ascospores in slits in the bark. They also report successful infections on healthy fruit with spores inserted in punctures and one successful experiment in infecting picked fruit in a moist chamber by spores applied to the unbroken skin. Scott (73) also has made successful inoculations of apples with conidia without puncture.

It will be noted that very few cases have been reported of successful infection of apples without punctures, and much more information is needed in regard to the exact time and method by which infection of the apple takes place. The occurrence of conidia-producing cankers on branches is too rare in most cases, in the East at least, to account for the great prevalence and immense number of the infections which are found during favorable seasons.

APPLE TO BEAN.

Halsted (40) reports successful inoculation of bean pods from apple by the introduction of a portion of the decayed tissue or spores. This is the only successful inoculation of beans with the apple anthracnose that has been reported, and in view of the failure of other investigators to secure the same results it does not seem advisable without verification to give it much weight in determining the specific relationship between the two forms occurring on these hosts.

APPLE TO GRAPE.

On October 14 eight berries of mature Niagara grapes were inoculated by puncture with conidia from apples. Eight others were inoculated by puncture with conidia from a culture. At the end of two weeks the first eight all showed rot and acervuli had formed on five berries. At the end of the same period the other lot all showed rot, but only two bore acervuli.

APPLE TO PUMPKIN.

One mature pumpkin was inoculated by puncture with conidia of *Glomerella* from an apple. No definite result was obtained, as the pumpkin soon decayed from other causes.

AVOCADO TO APPLE.

On December 17 three apples were inoculated by puncture, using conidia from a fruit of avocado. At the end of the week all showed decayed spots 1 inch in diameter at the point of inoculation with acervuli present in two cases. The other spot was smaller with no acervuli present at first, but many developed a little later.

AVOCADO TO BEAN.

On June 4 six young pods of wax bean were inoculated with conidia. No signs of infection ever appeared.

AVOCADO TO CABBAGE.

On November 8 young cabbage plants, bearing 8 to 10 leaves, were inoculated with conidia from a pure culture. Inoculations were made by puncture and by surface application. No signs of infection ever appeared on the inoculated leaves.

AVOCADO TO COTTON.

On April 1 three open cotton flowers were inoculated by applying conidia in a drop of sterile water to the stigma of the flower. The flowers were then covered with paper bags. No signs of infection had appeared at the end of two weeks, and no conidia developed on the bolls when removed and placed in moist chamber.

On November 8 bolls one-half grown were inoculated with conidia from a pure culture. Part of the inoculations were made on the surface, the others by puncture. No signs of infection appeared at the end of a month.

AVOCADO TO RUBBER PLANT.

Leaves were inoculated with conidia from pure culture, some applied to the surface and some by punctures. No signs of infection followed in either case.

AVOCADO TO TEA.

On November 8 young leaves were inoculated by both surface and puncture methods with conidia from a pure culture. No signs of infection appeared at the end of a month.

BEAN TO APPLE.

On September 30 four apples were inoculated by puncture with conidia from a bean pod. No signs of infection had appeared at the end of a month.

On July 25 seven apples were inoculated by puncture with conidia from a green bean pod. These fruits decayed after a month but no acervuli formed. Cultures made from the decayed spots produced only a sterile mycelium somewhat resembling that of *Gloeosporium lindemuthianum*. Positive identification was impossible without spore formation.

On October 4 twelve Willow Twig apples were inoculated by puncture with conidia from a bean pod. No signs of infection followed.

On October 6 four Willow Twig apples were inoculated on the surface with conidia from a bean pod. At the end of a month no signs of infection had appeared. The same experiment was repeated November 2 with the same result.

On October 6 four apples were inoculated by punctures with conidia from a bean pod. No signs of infection had appeared at the end of a month.

In December three Willow Twig apples were inoculated by puncture with conidia from a bean pod. No signs of decay occurred at the end of a month.

Later, three other mature apples were inoculated by puncture with conidia from culture. No decay followed and no acervuli developed. Twenty-nine other apples were inoculated by puncture with conidia of the bean *Glomerella* at different times during the season. In no case did decay or development of acervuli follow. In eight other cases also where conidia were applied to the surface of apples no infection occurred. These experiments seem to indicate that the *Glomerella* on the bean is physiologically different from that on the apple.

BEAN TO BEAN.

On June 4 six young pods of wax beans 2 inches long were inoculated by applying conidia from a bean pod to the surface. The plants were covered with a bell jar. No signs of infection ever appeared on these pods.

On June 5 the same experiment was repeated with the same result. The reason for the failure of these inoculations is not clear.

BEAN TO COTTON.

On July 16 four young bolls were inoculated by puncture with conidia from a bean pod. Small, dark, sunken areas developed about the point of inoculation in all, the same as with inoculations from cotton to cotton made at the same time. No acervuli appeared except on one of the bolls after removal to a moist chamber. These acervuli may not have arisen from the original inoculation from the bean.

BEAN TO PUMPKIN.

A mature pumpkin was inoculated by puncture with conidia from a culture from bean. No signs of infection followed.

BEAN TO HUBBARD SQUASH.

A mature squash was inoculated by puncture with conidia from a culture of the bean *Glomerella*. No decay followed and no acervuli formed.

BEAN TO TOMATO.

Four green tomato fruits were inoculated by puncture with conidia from wax beans. No decay followed and no acervuli formed.

BEAN TO WATERMELON.

A nearly mature watermelon was inoculated by puncture with conidia from a bean culture. No signs of infection followed.

It will be observed that no successful inoculations from bean to cucurbits were made. These results agree with those of Edgerton (30) but not with those of Halsted (39).

CAMELLIA TO BEAN.

On June 4 five young pods of bean grown in the greenhouse were inoculated by surface application of conidia in sterile water. No signs of infection followed.

On June 5 the same experiment was repeated with six pods, but without success.

CARYOTA TO COTTON.

On April 1 stigmas of three cotton flowers were inoculated by applying conidia in sterile water to the surface. The young bolls soon dropped, but when placed in moist chamber no conidia developed.

CHERIMOYA TO APPLE.

On October 2 three apples were inoculated by puncture with conidia from a culture. Decay followed about the points of inoculation in one week and acervuli were produced.

CHERIMOYA TO GRAPE.

On October 4 eight mature berries were inoculated by puncture with conidia from a culture. At the end of two weeks all the grapes were decayed and seven showed acervuli.

CINNAMON TO COTTON.

On April 1 three flowers were inoculated by the application of conidia in sterile water to the stigmas. No signs of infection followed, but the young bolls soon fell off. These bolls were kept in moist chamber for several weeks, but no conidia or acervuli developed.

COTTON TO APPLE.

Mature fruit was inoculated by puncture with conidia from a pure culture of the cotton fungus. A slight decay appeared in two weeks and a few acervuli with setæ bearing spores were found. At the end of a month the decayed spots had become larger and colored sporophores were also found mixed with the setæ.

On October 6 four apples were inoculated by applying conidia from cotton cultures to the surface. At the end of three weeks there was no sign of infection or decay.

On July 25 four apples were inoculated by puncture with conidia from a cotton boll. A slight decay appeared on two at the end of a month. At the end of one and one-half months the spots were three-fourths of an inch in diameter. Cultures made from the pulp from these spots produced acervuli and conidia with setæ, also brown septate conidia, such as are mentioned by Clinton (19). Two apples inoculated later in the same way produced practically the same result. The development of rot was very slow.

On October 6 four apples were inoculated by puncture using conidia from cultures made from the apple which was originally inoculated from cotton. Three of these apples showed small rotten spots at the end of 8 days. At the end of 20 days all showed rot and two produced acervuli. No typical setæ were found, but some brownish sporophores occurred which were rather intermediate in form between sporophores and setæ. This second generation of the cotton fungus on the apple developed much more rapidly than the first generation and indicated the possibility of its soon developing fully as fast as the form from the apple. This experiment and similar ones with other hosts appear to indicate that these organisms under certain conditions may rather quickly adapt themselves to different hosts though retaining their specific morphological characters. These results also suggest the possibility of the apple acting as a bridging host in some instances. This is in accord with the work of Salmon (68) on mildews and with that of Ward (94) on rusts.

COTTON TO BEAN.

On June 4 six young pods from a greenhouse plant were inoculated by applying conidia in sterile water from a cotton boll to the surface. No signs of infection ever appeared.

COTTON TO COTTON.

On March 19 five flowers were inoculated by applying conidia in sterile water from a cotton boll to the stigmas. All the bolls soon turned black and nearly all dropped off. One boll that remained on the plant about two weeks before it died became half covered with acervuli.

On June 24 six young bolls were inoculated by puncture with conidia from a cotton boll. In about two weeks small, dark, sunken spots had formed on all and four showed acervuli.

COTTON TO PUMPKIN.

On November 2 a pumpkin was inoculated by puncture with conidia from a pure culture of the cotton fungus. No signs of infection ever appeared.

COTTON TO HUBBARD SQUASH.

A squash was inoculated by puncture with conidia from a pure culture. No signs of infection ever appeared.

COTTON TO WATERMELON.

On November 2 a watermelon was inoculated by puncture with conidia from a pure culture from cotton. No rot followed, but a slight development of hyphæ and a few acervuli formed at the puncture. Spore-bearing setæ were present in these acervuli, as is usually the case with *Glomerella gossypii*.

CRANBERRY TO APPLE.

On April 27 six sound apples were inoculated by puncture with conidia from a pure culture. No rot or acervuli had developed at the end of a month. Later inoculations produced a slight decay in one instance and a few acervuli formed.

CRANBERRY TO SWEET PEA.

On April 6 stems and young leaves of young plants in the greenhouse were inoculated with ascospores in sterile water applied to the surface. No signs of infection ever appeared.

CURCULIGO TO COTTON.

On April 2 three flowers in greenhouse were inoculated by applying conidia in sterile water to the stigmas. No signs of infection appeared, but the young bolls dropped off. They were placed in a moist chamber, but no acervuli developed.

• DEWBERRY TO APPLE.

On October 2 three apples were inoculated by puncture with conidia from a culture from dewberry. At the end of a month only one apple showed a decayed spot, 1.75 inches in diameter. Small decayed spots occurred on the other two apples at points of inoculation 26 days later.

On October 12 four Willow Twig apples were inoculated by puncture with conidia from a culture. At the end of three weeks only one fruit showed development of rot, about 1.75 inches in diameter.

On October 26 three apples were inoculated by puncture with conidia from culture from the apple previously inoculated from dewberry. Only a slight decay occurred about the point of inoculation after several weeks and no acervuli formed. Cultures made from these decayed spots produced acervuli.

DEWBERRY TO APPLE TO AGAR TO APPLE.

On December 7 three apples were inoculated by puncture with conidia from an agar culture made from the first apples inoculated from the dewberry. Infection followed in all cases. Decayed spots 0.5 to 0.75 inch in diameter developed in six days, but no acervuli were produced.

DEWBERRY TO APPLE TO APPLE TO AGAR TO APPLE.

On January 3 three apples were inoculated by puncture with conidia from a pure culture made from the second generation of the dewberry fungus on apples. Infection followed in all cases. The decayed spots developed more rapidly than in the previous generation and abundant acervuli were formed.

On January 10 three apples were inoculated by puncture with conidia from a culture from the second generation grown on apple. Infection followed in all cases. Decayed spots an inch in diameter developed in 10 days and numerous acervuli appeared. These experiments seem to indicate that the dewberry form of *Glomerella* becomes quickly adapted to growth on apples, developing in the third generation about as rapidly as the fungus taken directly from apples and producing typical rot and acervuli.

DEWBERRY TO GRAPE.

On October 16 eight berries were inoculated by puncture with conidia from a culture from the same strain of the dewberry *Gloeosporium* used in the inoculations with apples. At the end of two weeks some rot was found, but no acervuli were ever produced.

FIG TO APPLE.

On September 14 four apples inoculated by puncture with conidia from a pure culture from the fig produced decay of the usual appearance of bitter rot, and acervuli were formed.

On October 2 three apples were inoculated by puncture with conidia from a pure culture from the fig. Infection followed in all cases and decay developed as rapidly as in inoculations made directly from apple to apple and typical acervuli also developed as shown in Plate XVI, figure 7.

FIG TO FIG.

Eight nearly mature figs were inoculated, four by puncture with conidia from cultures and four by application of the same to the unbroken surface of the fruit. Rot developed in all cases and acervuli formed. There is some doubt about this experiment, however, on account of the fact that three out of the seven checks used also developed rot.

FIG TO GRAPE.

Eight mature berries were inoculated by puncture with conidia from a pure culture from the fig. Most of the berries were rotten at the end of three weeks and three showed acervuli.

FICUS LONGIFOLIA TO RUBBER PLANT.

The under side of a young leaf attached to a plant was inoculated by placing conidia from a pure culture in sterile water on the uninjured surface and covering the spot with a Van Tiegham cell. At the end of 24 days there was no sign of infection. The leaf was then removed from the plant and placed in a moist chamber. Acervuli developed on the inoculated spot after two weeks but not on the check spot covered in the same way.

GOOSEBERRY TO APPLE.

On December 7 three apples were inoculated by puncture using hyphæ and probably ascospores from a pure culture containing masses of mature perithecia. On December 15 two of the apples showed rotten spots 1 cm. in diameter at the points of inoculation and the third a discoloration of the skin. By January 7 the first two apples were half rotten and the third about one-third decayed, and two of them produced acervuli. Cultures made from these apples produced both acervuli and perithecia of the fungus, the perithecia predominating.

GRAPE TO APPLE.

In four different experiments in which apples were inoculated by puncture with conidia from cultures from grapes or direct from the host typical bitter-rot followed and acervuli developed.

On August 19 eight Smokehouse apples were inoculated with conidia from rotten grapes from another source. This strain of the fungus appeared to be weak or not adapted to development on apples. Rot developed on only two of the inoculated fruits. The spots were small and increased very slowly and no acervuli were produced. Cultures were made from these spots.

GRAPE TO APPLE TO AGAR TO APPLE.

On August 24 six Smokehouse apples were inoculated by puncture with conidia from the culture made from apples inoculated from grape as mentioned above. Decay developed very slowly about the point of inoculation but a little faster than in generation 1. Finally some acervuli were produced on all but one of the apples.

On September 18 the above experiment was repeated with six Smokehouse apples. The development of rot this time was somewhat faster than before and acervuli developed on all.

GRAPE TO AGAR TO APPLE TO AGAR TO APPLE TO APPLE.

Four apples were inoculated by puncture with conidia from an apple inoculated with the third generation of the fungus from the grape. Rot developed about as rapidly at the point of inoculation on these fruits as is usual in transfers directly from apple to apple and at the end of 8 days acervuli were found.

GRAPE TO AGAR TO APPLE TO GRAPE.

On September 23 twelve ripe berries were inoculated by puncture with conidia from an apple. Only four developed the usual rot followed by acervuli. The others softened somewhat but no acervuli formed.

GRAPE TO AGAR TO GRAPE.

On September 23 twelve ripe berries were inoculated by puncture with conidia from a culture from a grape. At the end of two weeks five were rotten and acervuli had formed. Seven of these eventually decayed and showed acervuli.

GRAPE TO AGAR TO APPLE TO TOMATO.

On September 29 four green tomatoes were inoculated by puncture with conidia from a culture from a grape. Slight decay followed in only one case, but perhaps not from the inoculation. No acervuli were ever produced.

GRAPE TO PUMPKIN.

A pumpkin was inoculated by puncture with conidia from a culture from a grape. Rot developed rapidly and acervuli formed.

GRAPE TO HUBBARD SQUASH.

A nearly mature squash was inoculated by puncture with conidia from a culture from a grape. Rot developed very slowly at one point of inoculation only. A few acervuli were found at the end of a month.

GRAPE TO WATERMELON.

A nearly mature watermelon was inoculated with conidia by puncture from a culture from a grape. Rot developed rapidly at the point of inoculation and numerous acervuli formed.

GUAVA TO APPLE.

Two apples were inoculated by puncture with conidia from a culture from leaves of guava. Rot developed at the points of inoculation about as rapidly as in the case of transfers from apple to apple. Acervuli were present at the end of a week. No setæ were found.

GUAVA TO BEAN.

Six young pods of a wax bean from the greenhouse were inoculated by surface application of conidia from guava. No signs of infection ever followed.

GUAVA TO COTTON.

Three flowers of a cotton plant from the greenhouse were inoculated by applying conidia from guava to the surface of the pistil. No signs of infection were found at the end of two weeks, but two of the small bolls which developed from the inoculated flowers developed acervuli with setæ when placed in a moist chamber.

GUAVA TO PUMPKIN.

A pumpkin was inoculated by puncture with conidia from a culture from guava leaves. Rot developed rapidly and acervuli were produced in abundance.

GUAVA TO HUBBARD SQUASH.

A squash was inoculated by puncture with conidia from a culture from guava leaves. No rot appeared and no acervuli developed.

GUAVA TO WATERMELON.

A nearly mature watermelon was inoculated by puncture with conidia from a culture from guava leaves. Rot developed rather rapidly. Numerous acervuli were produced, as shown in Plate XVIII.

LEMON TO APPLE.

On September 14 four Willow Twig apples were inoculated by puncture with conidia from a culture from a lemon. Rot of the usual appearance developed rapidly in all cases and typical acervuli formed.

On October 2 three apples were inoculated by puncture with conidia from a culture. Rot developed in all cases. The spots were 2 centimeters in diameter at the end of a week and acervuli were present.

LEMON TO CABBAGE.

On December 17 leaves of a young cabbage plant in the greenhouse were inoculated by puncture with conidia from a lemon leaf. No signs of infection ever followed.

LEMON TO COTTON.

On December 17 leaves and bolls were inoculated by puncture with conidia from lemon leaves. No signs of infection were found at the end of a month.

LEMON TO ORANBERRY.

On December 17 leaves of a plant from the greenhouse were inoculated by puncture with conidia from a lemon leaf. No signs of infection were ever seen.

LEMON TO GRAPE.

On October 14 eight mature berries of Niagara grapes were inoculated by puncture with conidia from a culture. At the end of two weeks most of the berries were rotten and three bore acervuli.

LEMON TO ORANGE.

On December 17 orange leaves were inoculated by puncture with conidia from a lemon leaf. No signs of infection ever followed.

LEMON TO RUBBER PLANT.

On December 17 leaves on a living plant were inoculated by puncture with conidia from a lemon leaf. No signs of infection ever followed.

LEMON TO TEA.

On December 17 leaves of a living plant were inoculated by puncture with conidia from a lemon leaf. No signs of infection were found at the end of a month.

LOQUAT TO BEAN.

On June 4 six young pods from a greenhouse plant were inoculated by immersion in sterile water containing conidia. No signs of infection ever followed.

MANDARIN TO BEAN.

On June 4 six young pods from a greenhouse plant were inoculated by immersing beans in sterile water containing conidia. No signs of infection ever appeared.

MANDARIN TO COTTON.

On April 1 flowers of a greenhouse plant were inoculated by applying conidia to the stigmas. No signs of infection followed, but the young bolls soon dropped off. They were placed in a moist chamber, but no *Gloeosporium* developed.

MARANTA TO COTTON.

Stigmas of three flowers of a greenhouse plant were inoculated in the same manner as above. No signs of infection followed, but the young bolls dropped off. They were placed in a moist chamber, but no *Gloeosporium* developed.

ORANGE TO BEAN.

On June 5 six young pods on a greenhouse plant were inoculated by immersion in sterile water with conidia. No signs of infection ever appeared.

ORANGE TO COTTON.

On April 1 three flowers were inoculated by applying conidia to the stigmas. No indications of infection appeared, but the young bolls soon dropped. These bolls were kept in a moist chamber, but no *Gloeosporium* developed.

On June 24 five young bolls were inoculated by puncture with conidia from this host. Two developed slight decay and when removed to a moist chamber acervuli developed. Six others inoculated in the same way a little later showed scarcely any signs of decay about the point of inoculation but developed acervuli when removed to a moist chamber.

ORANGE TO RUBBER PLANT.

On February 4 two leaves of a small plant in the laboratory were inoculated by making a slight incision across the midrib near the tip and immersing the leaves in sterile water containing conidia from a culture. After five weeks no signs of infection were apparent. The leaf was removed from the plant, its surface thoroughly washed with corrosive-sublimate solution, and placed in a moist chamber. Twelve days afterwards, the leaf showed abundant acervuli extending about 3 inches from the tip. The two checks treated in the same manner throughout produced no Gloeosporium when kept in a moist chamber.

ORANGE TO TEA.

On February 4 two leaves of a growing plant in the laboratory were inoculated by making a slight incision in the midrib and immersing the leaf in sterile water containing conidia. A check was also treated in the same manner but not inoculated. The inoculated leaf developed immature acervuli on a small dead area surrounding the puncture while still attached to the plant. The check leaf was removed and placed in a moist chamber, but no Gloeosporium developed. Another leaf, however, on the same plant which appeared healthy was removed and placed in a moist chamber and this developed abundant acervuli, which indicates that it is practically impossible to determine whether or not a leaf or any portion of a plant already contains the fungus in a dormant condition. Results of experiments of this kind are thus shown to be somewhat uncertain.

PEPPERWORT TO COTTON.

Stigmas of two cotton flowers from the greenhouse were inoculated by the application of conidia in sterile water. The young bolls soon dropped off. They were kept in a moist chamber but no Gloeosporium developed.

PHORMIUM TO CABBAGE.

Five young plants in pots in the laboratory were sprayed with distilled water containing conidia and then covered with a bell jar. Leaves of both inoculated plants and checks soon turned yellow and dropped off. All these leaves were placed in moist chambers. Acervuli of Gloeosporium appeared on the inoculated leaves but not on the check. In two cases acervuli were produced on the inoculated leaves while still attached to the plant.

PITCAIRNIA TO BEAN.

Six young pods on a plant in the greenhouse were inoculated by immersion in sterile water containing conidia. No signs of infection ever appeared.

PITCAIRNIA TO COTTON.

The stigmas of two flowers of a greenhouse plant were inoculated with conidia in sterile water. The young bolls soon dropped off. These were placed in a moist chamber, but no *Gloeosporium* ever developed.

POMELO TO APPLE.

Three apples were inoculated by puncture with conidia from a culture. Infection followed in all cases. Spots 2 centimeters in diameter developed at the end of a week and acervuli formed.

POMELO TO GRAPE.

Eight mature berries of a Niagara grape were inoculated by puncture with conidia from a culture. At the end of two weeks the berries were mostly rotten, and acervuli were found on six of them.

POMELO TO POMELO.

Two sound fruits were inoculated by applying conidia in sterile water to the uninjured surface. The conidia germinated, and a slight development of mycelium with scattered conidia and chlamydospores appeared on the surface but the tissue beneath remained sound. No rot developed. In another case the same experiment was tried, applying the spores to the surface which had been injured by red spiders. The results were exactly the same as in the case just mentioned. No rot developed.

PRIVET TO BEAN.

Six young pods from a greenhouse plant were inoculated by immersion in sterile water containing conidia. No signs of infection ever appeared.

RUBBER PLANT TO FIG.

Four figs were inoculated by puncture with conidia from a leaf. Rot developed in all cases. Four other fruits were inoculated by application of conidia in sterile water to the uninjured surface of the figs. Rot developed but did not appear to start immediately at the point of application of the spores and as one of the checks in this experiment also developed rot the results are uncertain. Both lots of figs are shown in Plate XVII.

TABLE IV.—Results of inoculations as reported by other investigators—Continued.

Host.			Method of inoculation.	Material used.	Source of material.	Result.	Experimenter.
Original.	Inoculated.	Part inoculated.					
Apple.....	Plum to tomato.	Fruit.....	Puncture.	C.....	Host.....	Success.	Cobb, 1904.
Do.....	Quince.....	Green fruit.....	do.....	C.....	Host.....	Failure.	Clinton, 1902.
Do.....	do.....	Fruit.....	do.....	C.....	Host.....	Success.	Cobb, 1904.
Do.....	do.....	do.....	do.....	C. or H.	do.....	do.....	Halsted, 1892.
Do.....	Sweet pea.....	Young leaves.....	Surface.....	C.....	Culture.....	do.....	Edgerton, 1908.
Do.....	do.....	Seedlings.....	do.....	C.....	Host.....	do.....	Sheldon, 1908.
Do.....	do.....	do.....	Puncture.....	C.....	do.....	do.....	Taubenhaus, 1911.
Do.....	do.....	do.....	Surface.....	C.....	do.....	do.....	Do.
Do.....	Tomato.....	Green fruit.....	Puncture.....	C.....	do.....	do.....	Clinton, 1902.
Do.....	do.....	Fruit.....	do.....	C.....	Host.....	do.....	Cobb, 1904.
Do.....	do.....	do.....	do.....	C. or H.	do.....	do.....	Halsted, 1892.
Asclepias.....	Apple.....	do.....	do.....	C.....	do.....	Doubtful.	Edgerton, 1908.
Avocado.....	Pear.....	Fruit on tree.....	do.....	C.....	do.....	Rot, but not typical.	Taubenhaus, 1911.
Do.....	Sweet pea.....	Seedlings.....	Surface.....	C.....	do.....	Failure.	Do.
Do.....	do.....	do.....	Puncture.....	C.....	do.....	do.....	Do.
Banana.....	Apple.....	Fruit.....	do.....	C.....	Host.....	do.....	Cobb, 1904.
Do.....	do.....	do.....	do.....	C.....	do.....	do.....	Laubert, 1910.
Do.....	Date to plum.....	do.....	Puncture.....	C.....	Host.....	Success.	Cobb, 1904.
Do.....	Lemon.....	do.....	do.....	C.....	do.....	Doubtful.	Do.
Do.....	Passion fruit.....	do.....	do.....	C.....	do.....	do.....	Do.
Do.....	do.....	do.....	do.....	C.....	do.....	Very doubtful.	Do.
Do.....	Peach.....	do.....	do.....	C.....	do.....	do.....	Do.
Do.....	Pear.....	do.....	do.....	C.....	do.....	Success.	Do.
Do.....	Quince.....	do.....	do.....	C.....	do.....	do.....	Do.
Bean.....	Alfalfa.....	Stem and leaves.....	Surface.....	C.....	do.....	Failure.	Edgerton, 1910.
Do.....	Apple.....	Fruit.....	do.....	C.....	do.....	do.....	Edgerton, 1908.
Do.....	do.....	Ripe fruit.....	do.....	C.....	Pure culture.....	do.....	Edgerton, 1911.
Do.....	Bean.....	Leaves.....	Surface.....	C.....	Culture.....	Success.	Edgerton, 1910.
Do.....	do.....	Stems.....	do.....	C.....	do.....	do.....	Do.
Do.....	do.....	Pods.....	do.....	C.....	do.....	do.....	Do.
Do.....	Citron.....	Fruit.....	Puncture.....	C.....	Host.....	do.....	Halsted, 1893.
Do.....	Cotton.....	do.....	Surface.....	C.....	do.....	Failure.	Edgerton, 1910.
Do.....	Cucumber.....	Leaves, stems, fruit.....	do.....	C.....	do.....	do.....	Do.
Do.....	Eggplant.....	Fruit.....	Puncture.....	C. or H.	Host.....	Success.	Halsted, 1892.
Do.....	Pea.....	Leaves.....	Surface.....	C.....	do.....	Failure.	Edgerton, 1910.
Do.....	Pear.....	Fruit.....	Puncture.....	C. or H.	Host.....	Success.	Halsted, 1892.
Do.....	Pepper.....	do.....	do.....	do.....	do.....	do.....	Do.
Do.....	Perfumum.....	do.....	do.....	do.....	do.....	do.....	Do.
Clover.....	Apple.....	Ripe fruit.....	do.....	C.....	Pure culture.....	Failure.	Edgerton, 1911.
Coffee.....	do.....	Fruit.....	do.....	C.....	do.....	Success.	Edgerton, 1908.
Do.....	Fig.....	Leaves.....	do.....	C.....	do.....	do.....	Do.
Cotton.....	Apple.....	Fruit.....	do.....	C.....	do.....	do.....	Do.
Do.....	do.....	Ripe fruit.....	do.....	C.....	Pure culture.....	Failure.	Edgerton, 1911.
Do.....	Bean.....	Seed.....	Surface.....	C.....	do.....	do.....	Edgerton, 1910.
Do.....	Cotton.....	Very young bolls.....	do.....	C.....	Culture.....	(4)	Barre, 1909.
Do.....	do.....	Stems.....	Puncture.....	C.....	do.....	Failure.	Do.
Do.....	do.....	Leaves.....	do.....	C.....	do.....	do.....	Do.
Do.....	do.....	Petioles.....	Cut.....	C.....	do.....	Success.	Do.
Do.....	do.....	Flowers.....	Surface.....	C.....	do.....	do.....	Do.
Do.....	Fig.....	Green fruit.....	do.....	C.....	Pure culture.....	Partial success.	Edgerton, 1911.

¹ Development slow.

² *Citrullus vulgaris* var.

³ Takes poorly.

⁴ 60 per cent infected.

⁵ 37 per cent infected.

TABLE IV.—Results of inoculations as reported by other investigators—Continued.

Host.			Method of inoculation.	Material used.	Source of material.	Result.	Experimenter.
Original.	Inoculated.	Part inoculated.					
Dracaena....	Apple.....	Fruit.....	.....	C.....	.....	Success..	Edgerton, 1908.
Do.....	Fig.....	Leaves.....	.....	C.....	.....	do.....	Do.
Eggplant....	Bean.....	Pods ?.....	Puncture	C. or H.	Host.....	do.....	Halsted, 1892.
Do.....	Pepper....	Fruit.....	do.....	C.....	do.....	do.....	Do.
Fig.....	Apple.....	Ripe fruit..	.....	C.....	Pure culture	do.....	Edgerton, 1911.
Do.....	Bean.....	Seeds, stems, leaves,	Surface...	C.....	.....	Failure..	Edgerton, 1910.
Do.....	Fig.....	Green fruit..	.....	C.....	Pure culture	Success..	Edgerton, 1911.
Do.....	do.....	do.....	.....	C.....	Culture from branch.	do.....	Do.
Guava.....	Apple.....	Fruit.....	Puncture..	C.....	Host.....	Success..	Cobb, 1904.
Do.....	do.....	Picked fruit.	do.....	C.....	Culture.....	do.....	Sheldon, 1903.
Do.....	do.....	Un picked fruit.	do.....	C.....	do.....	do.....	Do.
Do.....	do.....	Young un-picked fruit.	do.....	C.....	.....	Failure..	Do.
Do.....	do.....	Picked fruit.	do.....	C.....	.....	Success..	Do.
Do.....	do.....	Twigs.....	do.....	C.....	.....	Failure..	Do.
Do.....	Banana....	Fruit.....	do.....	C.....	Host.....	Success..	Cobb, 1904.
Do.....	Bush bean..	Pods on vine	do.....	C.....	.....	do.....	Taubenhans, 1911.
Do.....	D a m s o n plum.	Fruit.....	do.....	C.....	Culture.....	do.....	Sheldon, 1906.
Do.....	Apple to hawthorn.	do.....	do.....	C.....	Host.....	do.....	Cobb, 1904.
Do.....	Passion vine	do.....	do.....	C.....	do.....	Failure..	Do.
Do.....	Pear.....	do.....	do.....	C.....	do.....	Success..	Do.
Do.....	do.....	do.....	do.....	C.....	do.....	V e r y doubtful.	Do.
Do.....	do.....	Fruit on tree	do.....	C.....	.....	Rot, but not typical.	Taubenhans, 1911.
Do.....	Quince....	Fruit.....	do.....	C.....	Host.....	Success..	Cobb, 1904.
Do.....	Quince to guava.	do.....	do.....	C.....	do.....	do.....	Do.
Do.....	Sweet pea..	Seedling ..	do.....	C.....	.....	Failure..	Taubenhans, 1911.
Do.....	do.....	do.....	Surface ..	C.....	.....	do.....	Do.
Kentia.....	Apple.....	Green fruit..	Puncture	C.....	Host.....	Success..	Cobb, 1904.
Mandrake...	do.....	Fruit.....	.....	C.....	.....	do.....	Taubenhans, 1911.
Do.....	Lima bean..	Pods on vine	Puncture	C.....	.....	do.....	Do.
Do.....	Pear.....	do.....	do.....	C.....	.....	do.....	Do.
Do.....	Sweet pea..	Seedling ..	do.....	C.....	.....	do.....	Do.
Do.....	do.....	Seedling ..	Surface ..	C.....	.....	do.....	Do.
Oak gail....	Apple.....	Fruit.....	.....	C.....	.....	do.....	Do.
Do.....	Lima bean..	Pods on vine	Puncture	C.....	.....	do.....	Do.
Do.....	Pear.....	Fruit.....	do.....	C.....	.....	do.....	Do.
Do.....	Sweet pea..	do.....	do.....	C.....	.....	do.....	Do.
Do.....	do.....	Seedling ..	Surface ..	C.....	.....	do.....	Do.
Orange.....	Apple.....	Fruit.....	.....	C.....	.....	Doubtful.	Edgerton, 1908.
Passion vine.	do.....	do.....	Puncture	C.....	Host.....	Failure..	Cobb, 1904.
Do.....	D a t e t o plum.	do.....	do.....	C.....	do.....	do.....	Do.
Do.....	Guava.....	do.....	do.....	C.....	do.....	do.....	Do.
Do.....	Peach.....	do.....	do.....	C.....	do.....	do.....	Do.
Do.....	Pear.....	do.....	do.....	C.....	do.....	do.....	Do.
Passion leaves	do.....	do.....	do.....	C.....	do.....	Success..	Do.
Passion vine.	Pepper....	do.....	do.....	C.....	do.....	Failure..	Do.
Do.....	Pineapple..	do.....	do.....	C.....	do.....	do.....	Do.
Do.....	Tomato....	do.....	do.....	C.....	do.....	Success..	Do.
Do.....	Quince....	do.....	do.....	C.....	do.....	Failure..	Do.
Pear.....	Banana....	do.....	do.....	C. or H.	.....	Success..	Halsted, 1892.
Do.....	Citron ? ..	do.....	do.....	do.....	.....	do.....	Do.
Do.....	Lemon.....	do.....	do.....	do.....	.....	do.....	Do.
Do.....	Pepper....	do.....	do.....	do.....	.....	do.....	Do.
Do.....	Tomato....	do.....	do.....	do.....	.....	do.....	Do.
Pepper.....	Apple.....	do.....	do.....	C.....	Host.....	do.....	Cobb, 1904.
Do.....	do.....	do.....	do.....	C. or H.	.....	do.....	Halsted, 1892.
Do.....	do.....	Ripe fruit..	.....	C.....	Pure culture	do.....	Edgerton, 1911.

1 *Citrus vulgaris* var.

TABLE IV.—*Results of inoculations as reported by other investigators—Continued.*

Host.			Method of inoculation.	Material used.	Source of material.	Result.	Experimenter.
Original.	Inoculated.	Part inoculated.					
Pepper	Banana.	Fruit.	Puncture	C. or H.		Success	Halsted, 1892.
Do.	Bean	Stem and leaves.	Surface.	C.		Failure.	Edgerton, 1910.
Do.	do.	Pod.	Puncture	C. or H.		Success	Halsted, 1892.
Do.	Fig.	Green fruit.		C.	Pure culture	do.	Edgerton, 1911.
Do.	Pear	Fruit.	Puncture	C.		do.	Halsted, 1892.
Do.	Perstimmon.	do.	do.	C.		do.	Do.
Poplar	Apple.	Ripe fruit.		C.	Pure culture	Partial success.	Edgerton, 1911.
Quince	do.	Fruit.	Puncture	C.	Host.	Success	Cobb, 1904.
Raspberry	do.	do.		C.		do.	Edgerton, 1908.
Rose	Bean	Picked pods.	Surface.	C.	Culture	Failure	Edgerton, 1910.
Rubber plant.	Rubber plant	Detached leaves.	do.	A.	do.	Success	Koorders, 1907.
Do.	do.	Seedling leaves.	do.	A.	do.	do.	Do.
Sarracnia.	Fig.	Leaves.		C.		do.	Edgerton, 1908.
Sassafras	Apple.	Fruit.		C.		do.	Taubenhaus, 1911.
Do.	Lima bean	Pods on vine	Puncture	C.		do.	Do.
Do.	Pear	Fruit.	do.	C.		do.	Do.
Do.	Sweet pea.	Seedling	do.	C.		do.	Do.
Do.	do.	Seedling	do.	C.		do.	Do.
Do.	do.	do.	Surface.	C.		do.	Do.
Silver maple	Apple	Ripe fruit.		C.	Pure culture	do.	Edgerton, 1911.
Do.	Fig.	Green fruit.		C.	do.	do.	Do.
Sweet pea.	Apple.	Fruit.		C.		do.	Taubenhaus, 1911.
Do.	do.	Fruit on tree	Puncture	C.		do.	Do.
Do.	Bush bean	Pods on vine	do.	C.		do.	Do.
Do.	do.	do.	Surface	C.		Failure	Do.
Do.	Lima bean	do.	Puncture	C.		Success	Do.
Tomato	Apple.	do.		C. or H.		do.	Halsted, 1892.
Do.	Banana.	do.	do.	do.		do.	Do.
Do.	Bean	Pod.	do.	do.		do.	Do.
Do.	Eggplant.	Fruit.	do.	do.		do.	Do.
Do.	Pear	do.	do.	do.		do.	Do.
Do.	Pepper	do.	do.	C.	Culture	do.	Chester, 1893.
Do.	do.	do.	do.	C.		do.	Do.
Do.	do.	do.	Surface.	C.		Failure.	Do.
Do.	do.	do.	Puncture	C.		Success	Do.
Do.	Pepper to pepper.	do.	do.	C.		Failure	Do.
Do.	Pepper to squash.	do.	do.	C.		Success	Do.
Do.	Pepper to tomato.	do.	do.	C.		Failure	Do.
Do.	Tomato.	do.	Surface.	C.		Success	Halsted, 1892.
Do.	Quince.	do.	Puncture	C.		Failure.	Edgerton, 1908.
Watermelon.	Apple.	do.		C.		Success	Halsted, 1893.
Do.	Bean	do.	Puncture	C. or H.		do.	Do.
Do.	Citron	Picked fruit.	do.	do.	Host.	do.	Sheldon, 1904.
Do.	Cucumber.	Leaves	Surface.	do.	do.	do.	Do.
Do.	do.	Unpicked fruit.	Puncture	C.	do.	do.	Do.
Do.	do.	Picked fruit.	do.	C.	Culture	do.	Do.
Do.	Gourd.	Seedling	Surface.	C.	do.	do.	Do.
Do.	Muskmelon.	Unpicked fruit.	Puncture	C.		do.	Do.
Do.	do.	Seedling.	Surface.	C.	Culture	do.	Do.
Do.	do.	do.	do.	C.		do.	Do.
Do.	Pumpkin.	do.	do.	C.	Culture	Failure.	Do.
Do.	Pear	Fruit on tree	Puncture	C.		Success	Taubenhaus, 1911.
Do.	Sweet pea.	Seedling.	do.	C.		do.	Do.
Do.	do.	do.	Surface.	C.		do.	Do.
Yellow sweet clover.	Apple.	Ripe fruit.		C.	Pure culture	Failure	Edgerton, 1911.
Do.	Fig.	Green fruit.		C.	Culture from stem.	Partial success.	Do.

1 *Citrus vulgaris* var.

PARASITISM OF *GLOMERELLA*.

That *Glomerella* is an active parasite in certain races and under certain conditions would never be questioned by one who has had an opportunity to observe a severe attack of bitter-rot of the apple such as occurred in an orchard near Vienna, Va., in 1911. Several trees of Willow Twig apples well cared for and in a thrifty condition and bearing a good crop of fruit were attacked in July when the fruit was about half grown. Within a week or two nearly every apple on these trees showed bitter-rot spots which developed rapidly and soon destroyed the crop. This result was apparently due to a combination of favorable factors, the presence of a virulent race of the fungus, a susceptible variety of fruit (other varieties immediately adjoining showed little or no bitter-rot), and optimum conditions of temperature and moisture for infection and development.

Many races of *Glomerella* under ordinary conditions appear to be rather weak parasites. The different degrees and manifestations of parasitism among the fungi are so numerous and varied that it is very difficult to classify them satisfactorily in this respect. The possession of dormant hibernating hyphæ which infest the seeds of some annual plants, as in the case of the cotton and bean anthracnoses, the shoots of perennials, as in orange, and the leaves of evergreens, as in the case of the rubber plant, coffee, tea, citrus fruits, and other subtropical plants, indicates a considerable degree of specialization which would appear to give *Glomerella* a higher rank among parasites than the *Fusarium* forms of *Nectria* and closely related organisms. On the other hand, its ready growth on artificial culture media, dead organic matter and matured fruits suggests a low form of parasitism. As already mentioned, Appel and Wollenweber (1) have suggested that the fact that an organism will complete its life history on artificial culture media or dead organic matter is an indication that it is a saprophyte. As has already been pointed out, this suggestion does not seem to accord with the known facts.

The majority of the inoculation experiments which have been reported were performed by puncture of mature or nearly mature fruits. This method does not furnish the best proof of the parasitism of the organism. It is quite possible that the fungus would grow and develop rot under such conditions but still might not under natural conditions be able to gain entrance through the unbroken surface of the fruits.

The experiments of Edgerton (28), Rolfs (66), Barre (7, 8), Hasselbring (45), Bessey (13) and others, as well as some of those of the present writers, have shown that cross-inoculations can be successfully made by the application of spores to the uninjured stems, leaves, and flowers of living plants. Hasselbring (45) has shown a way in

which the appressoria, or chlamydospores, assist the fungus in gaining entrance to the tissues of the host. In the majority of cases the most probable explanation of the dormant infections which have been shown to be present in so many instances in leaves and fruit showing no external evidence of disease, is that the conidia or ascospores germinate whenever they come in contact with the plant surface under favorable conditions of temperature and moisture and produce appressoria, which are able to endure more unfavorable conditions than the spores and which in turn send a germ tube through the epidermis. This tube apparently penetrates at first but a very short distance and does little harm to the host cells, remaining in a dormant or inactive condition until the host becomes weakened or injured or the organ infected dies a natural death. Bodies resembling appressoria have been found on the surface of normal apple leaves upon which the fungus developed in a moist chamber and they are sometimes found in abundance on the surface of lemons and other citrus fruits. It is difficult positively to identify these bodies on a leaf surface and trace the germ tube in the tissue, and the writers have as yet been unable to devote the necessary time to this feature of the investigation to verify conclusively the suggested explanation of the facts observed.

Large series of microtome sections of presumably infected leaves, the unused portions of which developed the fungus when placed in a moist chamber, have been studied, but the presence of fungus hyphæ has not been demonstrated with certainty. This would be quite natural if the supposition that the dormant infection is restricted to a short hypha or germ tube just penetrating the surface is correct. The experiments with leaves in moist chamber, especially deciduous leaves, show that the discoloration of the tissue and the development of the fungus start at rather definite points on the leaves and spread from these in a more or less circular manner, as shown in Plate V. In the case of the citrus fruits there appears to be quite clear evidence, from the work of Rolfs (67), Bessey (12, 13), as well as from that of the writers with leaves and shoots in moist chambers that the fungus in some cases enters the stem by way of the flowers and works back through the tissue. The development of the fungus first in the petiole and along the midrib, as frequently happens in the case of orange and rubber plant leaves in moist chamber, would suggest this possibility, though in these latter cases the infection may have been localized on the petiole or midrib.

These organisms generally develop most rapidly and do most damage to nearly or quite mature fruit and have developed special methods of insuring their survival and distribution from season to season, not only by means of appressoria but by hibernating hyphæ in old fruits, leaves, and branches and by ascospores.

DIFFERENCES IN VIRILITY OF RACES FROM THE SAME HOST.

From the experiments of the writers it appears clear that there is considerable variation in the virility of different races or strains of *Glomerella* just as there is in their morphological characters. As mentioned in the records of inoculation experiments, conidia from cultures from different apples when inserted in the fruit showed considerable difference in the production of rot. Some of these races produced rot more slowly than those derived from other hosts. This fact increases the difficulty of developing a resistant variety of any host as a means of counteracting disease, as has been attempted with cotton and bean. Barrus (9) at first reported certain varieties of beans as entirely resistant to the anthracnose fungus with which he was working. Later he (10) found that when other strains of the fungus were used these varieties became infected with the disease. The observations of Scott (73) that the Ben Davis apple is very severely attacked by bitter-rot in Arkansas, while it is seldom seriously injured by the disease in Virginia, although other varieties in the same locality are destroyed, is also perhaps to be accounted for by the presence of strains of different virility in the two regions. A variety or race of a host may be very resistant to a certain strain of a fungus but may succumb to a more virile strain of the parasite at any time. This also accords with the results of animal pathologists as reported by Slack (82) and others in the case of pathogenic bacteria. We must not fail to recognize that the parasite is apparently capable of as great variability in every direction as the host.

METHODS OF PREVENTION AND CONTROL.

In the cases in which these diseases are known to be transmitted through the seed, as in cotton and beans, the trouble may be largely prevented by the careful selection of fungus-free seed, as shown by Barre (7) for cotton and Whetzel (95) for beans. The work of Duggar (27) and Barre (7) with cotton, Barrus (9, 10) with beans, and Bain and Essary (4) with clover seems to indicate that more or less resistant varieties may be obtained. In this connection it should be constantly borne in mind, as already stated, that the fungous parasite is an organism evidently subject to the same laws and possesses the same or possibly greater capacity for variation, not only in form but in virility, as its host plants. This has been demonstrated by the writers' work, as indicated elsewhere in this paper, and is confirmed by the experience of Barrus (10) and others. Sanitary measures and eradication methods will prove helpful. Cutting out and destruction of cankers where they occur, the destruction or burying through cultivation of mummied fruits and infested leaves, should be practiced wherever practicable.

Spraying is, however, the most important general method of preventing disease caused by *Glomerella*. The work of Scott (73) and others with the bitter-rot of apples has shown that the proper application of Bordeaux mixture will largely protect fruit from this disease. Rolfs (66) has shown that the wither tip of citrus fruits, due to *Glomerella*, can also be controlled by spraying. There is no reason to doubt that diseases of other plants caused by the same fungus can be largely prevented by the proper use of Bordeaux mixture. In determining dates for spraying it is important to first discover the natural infection periods and to spray the plants before infection occurs. As has already been indicated, a considerable part of the infection is brought about by the appressoria or chlamydo-spores. The germ tube from an appressorium having penetrated the epidermis of the host is apparently beyond the reach of injury by a fungicide; and this infection, though it may remain dormant more or less indefinitely under certain conditions, may also develop and cause serious injury under certain other conditions. The time and method of infection apparently varies in many cases, depending upon conditions which favor the production, dissemination, and germination of the spores.

SUMMARY.

(1) Most cultivated fruits and many other economic plants are attacked and seriously injured by fungous parasites of the genus *Glomerella*.

(2) These fungi pass through three stages in the course of their complete development and produce three kinds of spores—conidia, ascospores, and chlamydo-spores or appressoria. Until recently the two principal spore forms, conidia and ascospores, have been described and treated as distinct organisms.

(3) The conidial stage is most frequently observed and described, and is usually referred to one or the other of the form genera *Gloeosporium* and *Colletotrichum*. About 500 so-called species of conidial forms probably belonging to *Glomerella* are recorded.

(4) The genetic connection of the conidial with the ascogenous stage was first definitely proven with cultures in 1898 by Atkinson, working with *Glomerella (Gloeosporium) cingulata* (Stonem.) S. and v. S. found on privet. Since that date the life-history forms, races, and species of the organism from several other host plants has been recorded by Clinton, Stoneman, Edgerton, Sheldon, Koorders, and the present writers.

(5) The life histories of forms from 36 different host plants have been determined and recorded here. In 17 cases they were produced in pure cultures and in the other 19 cases they developed on the host either in a moist chamber or under natural conditions. In 31 cases they were first reported by the writers.

(6) In most of the forms studied neither morphological nor physiological differences sufficient for the segregation of species have been found. All the material from the 36 hosts is referred to three species of *Glomerella*, *G. cingulata*, which occurs on 34 of the hosts, *G. gossypii* on one, and *G. lindemuthianum* on one.

(7) *Glomerella cingulata* is exceedingly variable in all its characters so far as they have been studied. The cause of this variability is not yet clear. No constant or definite relation has been established between the cultural and other environmental conditions and the most important variations observed.

(8) The fungus is found to be present in many cases in apparently normal and healthy foliage, fruits, and sometimes in the stems of its hosts, as shown by its development and fructification on such portions of plants after they have been thoroughly washed in a corrosive-sublimate solution which has been shown to kill not only ascospores and conidia but also the chlamydospores or appressoria of the fungus. The chlamydospores or appressoria evidently send a germ tube through the epidermis of the host as shown by Hasselbring, and this remains in a quiescent condition until opportunity for further development occurs.

(9) Inoculation experiments with fruits have shown that most of the forms from different hosts will produce the characteristic *Glomerella* rot on fruits of other hosts. It is also shown that there is great variability in the virility of different races or strains of the fungus from the same host. In one experiment races from the lemon, grape, and fig produced more serious cases of bitter-rot of apple than a race of the fungus derived from apples. These facts are of great importance in connection with the selection and production of disease-resistant varieties of plants.

(10) The production or nonproduction of the perithecial stage of *Glomerella* appears to be a fairly well-fixed hereditary race character. Where a race of the fungus has been obtained by repeated trial of spores from different sources and races which develops both conidial and ascogenous fructifications in cultures it continues to produce them for many generations. An ascogenous race from *Persea* was grown for 23 generations from conidia. The last generation produced perithecia about as abundantly as the first. No evidence has been obtained to indicate that the production of perithecia is controlled by any of the ordinary conditions of nutriment or environment.

(11) *Glomerella* is a parasite which has apparently developed special features, the most important of which is its method of infection by means of chlamydospores, or appressoria, and its ability to remain in a dormant or quiescent condition until the host plant becomes weakened or injured in some way or until specially favorable

conditions for the growth of the fungus occur. In many cases the fungus never develops further until the infected portion of the host dies. The development of the fungus in seeds as in the case of cotton and bean is also evidently a special feature of *Glomerella* to insure its passing the winter and reaching the new crop. In nature the perithecial form, as in the case of many other pyrenomycetes, develops normally only after the death of the host tissues.

(12) The experiments of Scott, Rolfs, and others have shown that the diseases of apples and citrus fruits caused by *Glomerella* can be satisfactorily controlled by spraying with Bordeaux mixture. It is probable that this method can be successfully used in the prevention of the diseases of other plants caused by this fungus. The selection of fungus-free seed is also an effective method of reducing loss from disease, as shown by Barre for cotton and Whetzel for beans. Eradication and destruction of dead and diseased parts of infected plants are also important. The selection and breeding of resistant varieties may also be practicable in some cases, as indicated by the work of Bain and Essary with clover.

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EXPLANATION OF PLATES.

[Plates I, II, and III are from photomicrographs made by Mr. Lon A. Hawkins, of the Office of Fruit-Disease Investigations. All asci are magnified 450 diameters and the separate ascospores 700 diameters.]

Plate I. Figs. 1 to 15.—Photomicrographs of asci and ascospores of *Glomerella*, from various hosts. Fig. 1.—From grape. An ascus from a glycerin mount stained in eosin, from dried corn-meal culture 325d. Fig. 1a.—From grape. Ascospores from a fresh glycerin mount, unstained, from corn-meal agar culture 1373b. Fig. 2.—From grape. An ascus from a fresh glycerin mount stained in gentian violet, from a corn-meal agar culture 1238h. Fig. 2a.—From grape. Ascospores from same culture as figure 2. Fig. 3.—From apple. An ascus from a fresh glycerin mount stained in eosin, from a dried specimen on fruit. Fig. 3a.—From apple. Ascospores from same source as figure 3. Fig. 4.—From cranberry. An ascus from an old mount, unstained, from culture 756 from skin and pulp of New Jersey berry. Fig. 4a.—From cranberry. Ascospores from same mount as figure 4. Fig. 5.—From black raspberry. An ascus from a 2-year-old formalin mount, unstained, from plate culture from canes from Shelbyville, Tenn. Fig. 5a.—Ascospores from the same mount as figure 5. Fig. 6.—From pomelo. An ascus from a formalin mount 2 years old, unstained, from a leaf from a greenhouse of the Department of Agriculture, kept in a moist chamber. Fig. 6a.—Ascospores from the same mount as figure 6. Fig. 7.—From lemon. An ascus from a mercuric chlorid mount 1 year old, unstained, from a leaf from the Department greenhouse, kept in a moist chamber. Fig. 7a.—Ascospores from the same mount as figure 7. Fig. 8.—From orange. An ascus from a glycerin mount, stained with eosin, from a leaf from the Department greenhouse, kept in a moist chamber. Fig. 8a.—Ascospores from the same mount as figure 8. Fig. 9.—From guava. An ascus from a fresh glycerin mount from dried specimen, unstained, from a leaf from the Department greenhouse, kept in a moist chamber. Fig. 9a.—Ascospores from a fresh glycerin mount from a dried specimen, stained in eosin, from a leaf from the department greenhouse, kept in a moist chamber. Fig. 10.—From avocado. An ascus from a mercuric chlorid mount 1 year old, unstained, from leaves from the Department greenhouse, kept in a moist chamber. Fig. 10a.—Ascospores from the same mount as figure 10. Fig. 11.—From loquat. An ascus from a glycerin mount, stained with eosin, from a leaf from the Department greenhouse, kept in a moist chamber. Fig. 11a.—Ascospores from the same mount as figure 11. Fig. 12.—From cotton. An ascus from an old slide, unstained, from a culture. Fig. 12a.—Ascospores from the same slide as figure 12. Fig. 13.—From bean. An ascus from an old formalin mount, unstained, from corn-meal culture 485a, from bean pods from Takoma Park, Md. Fig. 13a.—Ascospores from corn-meal culture 484 from same source as figure 13. Fig. 14.—From coffee. An ascus from a fresh glycerin mount from a dried specimen, stained in eosin, from a leaf from the Department greenhouse, kept in a moist chamber. Fig. 14a.—Ascospores from a fresh glycerin mount, stained in eosin, from a leaf from the Department greenhouse, kept in a moist chamber. Fig. 15.—From camellia. An ascus from a fresh glycerin mount from a dried specimen, unstained, from a leaf from the Department greenhouse, kept in a moist chamber. Fig. 15a.—Ascospores from a fresh glycerin mount from a dried specimen, unstained, from a leaf from the Department greenhouse, kept in a moist chamber.

Plate II. Figs. 16 to 29.—Photomicrographs of asci and ascospores of *Glomerella* from various hosts. Fig. 16.—From tea. An ascus from a fresh glycerin mount, stained in eosin, from leaves from the Department greenhouse, kept in a moist chamber. Fig. 16a.—Ascospores from an unstained glycerin mount from the same material as figure 16. Fig. 17.—From privet. An ascus from a 2-year-old formalin mount, unstained, from twigs from Digby, Nova Scotia. Fig. 17a.—Ascospores from same mount as figure 17. Fig. 18.—From rubber plant. An ascus from a glycerin mount from fresh specimen, stained, from leaves from the Department greenhouse, kept in a moist chamber. Fig. 18a.—Ascospores from a glycerin mount, stained in eosin, from the same source as figure 18. Fig. 19.—From *Ficus longifolia*. An ascus from a 1-year-old formalin mount, unstained, from leaves from the Department greenhouse, kept in a moist chamber. Fig. 19a.—Ascospores from same mount as figure 19.—Figure 20.—From honey locust. An ascus from an old mount, probably formalin, unstained, from corn-meal culture from leaves from the grounds of the Department of Agriculture. Fig. 20a.—Ascospores from same mount as figure 20. Fig. 21.—From spiral flag (*Costus speciosa*). An ascus from a fresh glycerin mount from dried specimen, stained in eosin, from a leaf from the Department greenhouse, kept in a moist chamber. Fig. 21a.—Ascospores from a 2-year-old formalin mount, unstained, from the same specimen as figure 21.—Fig. 22.—From *Curculigo* sp. An ascus from a formalin mount, 1 year old, slightly stained in methyl blue, from a leaf from the Department greenhouse, kept in a moist chamber. Fig. 22a.—Ascospores from the same mount as figure 22. Fig. 23.—From ebony (*Brya*). An ascus from a glycerin mount from a fresh specimen, stained in eosin, from a leaf from the Department greenhouse, kept in a moist chamber. Fig. 23a.—Ascospores from the same mount as figure 23. Fig. 24.—From chocolate (*Theobroma cacao* L.) An ascus from a glycerin mount from fresh material, stained in eosin, from a leaf from the Department greenhouse, kept in a moist chamber. Fig. 24a.—Ascospores from the same mount as figure 24. Fig. 25.—From Pitcairnia. An ascus from a fresh glycerin mount from dried specimen, stained in eosin, from a leaf from the Department greenhouse, kept in a moist chamber. Fig. 25a.—Ascospores from a glycerin mount, stained in eosin, from the same material as figure 25. Fig. 26.—From palm (*Hedyoscepe* sp.). An ascus from an old mount, probably in formalin, unstained, from a leaf from the Department greenhouse. Fig. 26a.—Ascospores from a fresh glycerin mount, stained with eosin, from a leaf from the Department greenhouse. Fig. 27.—From ginkgo. An ascus from an old mount, probably in formalin, unstained, from a leaf from the grounds of the Department of Agriculture. Fig. 27a.—Ascospores from the same mount as figure 27. Fig. 28.—From Caryota. An ascus from a mercuric chlorid mount, 1 year old, unstained, from a leaf from the Department greenhouse, kept in a moist chamber. Fig. 28a.—Ascospores from the same slide as figure 28. Fig. 29.—From fig. An ascus from a fresh glycerin mount, unstained, from corn-meal agar culture 1283d from conidia on fruit from Norfolk, Va. Fig. 29a.—Ascospores from the same mount as figure 29.

Plate III. *Glomerella cingulata*.—Three series of asci from different hosts, showing the wide range of variation observed. Photomicrographs from fresh glycerin mounts. Figs. 30 to 34.—From grape. All from cultures of the same origin. Fig. 30.—An ascus 101 μ long, from corn-meal agar slant culture 1373b from Vienna, Va. Fig. 31.—An ascus 87 μ long, from the same culture. Fig. 32.—An ascus 77.5 μ long, from the same culture. Fig. 33.—An ascus 70.5 μ long, from another tube from the same source. Fig. 34.—An ascus 54.5 μ long, from corn-meal agar culture 1373b. Figs. 35 to 39.—*Glomerella cingulata* from apple. Fig. 35.—An ascus 108 μ long, from corn-meal agar slant culture 1348k, from conidia on Willow Twig apple from Vienna, Va. Fig. 36.—An ascus 89.5 μ long, from the same culture as

- figure 35. Fig. 37.—An ascus $83\ \mu$ long, from same cultures as figures 35 and 36. Fig. 38.—An ascus $77\ \mu$ long, from same culture as figures 35, 36, and 37. Fig. 39.—An ascus $55\ \mu$ long, from corn-meal agar slant culture from apple leaves from Winchester, Va.—Figs. 40 to 44.—*Glomerella cingulata* from fig. Fig. 40.—An ascus $110\ \mu$ long, from corn-meal agar slant culture 1283d, from conidia on fruit from Norfolk, Va. Fig. 41.—An ascus $92.5\ \mu$ long, from same culture as figure 40. Fig. 42.—An ascus $85.5\ \mu$ long, from corn-meal agar slant 1283a, from same source as 1283d. Fig. 43.—An ascus $63.5\ \mu$ long, from corn-meal agar slant 1283e, from same source as 1283a. Fig. 44.—An ascus $56\ \mu$ long, from same culture as figure 43.
- Plate IV. Pomelo leaves showing development in moist chamber of numerous colonies of *Glomerella cingulata* on apparently healthy leaves for 9 days. The lower leaf 1 year younger than the upper. The colonies originated chiefly from the midrib.
- Plate V. *Glomerella cingulata* on pomelo leaves. Figure 1 shows development of numerous scattered colonies on apparently healthy leaves in moist chamber, evidently rising from separate points of infection. Figure 2 shows small leaf 1 year younger taken from the same plant and treated in the same manner. No fungus developed, as the leaf was apparently not infected.
- Plate VI. *Glomerella cingulata* on 2 orange leaves, showing the development of the fungus on apparently healthy leaves in a moist chamber and the localization of the colonies which evidently originated from separate points of infection. The rubber plant leaf at the right shows the development of the fungus from the petiole along the midrib. Acervuli first developed on the petiole, which has been removed.
- Plate VII. *Glomerella lindemuthianum* from bean. Six corn-meal agar cultures started from conidia from a single acervulus, showing the uniform character of cultures of this species and the characteristic dark mycelium usually producing acervuli only.
- Plate VIII. *Glomerella cingulata* from Persea. Ascospore generation 2, tube a, showing separate perithecia thickly covering the surface of the medium. Conidial generation 13, tubes b and c, showing chiefly acervuli. Conidial generation 14, tubes b and c, originated from generation 13, b and c, respectively, are strikingly different. Of generation 14, b shows chiefly acervuli and conidia and c chiefly perithecia, which are arranged in masses along the line where the spores were planted.
- Plate IX. *Glomerella cingulata* from Persea. Conidial generation 9, tube a, shows numerous scattered perithecia and a few acervuli near the bottom. Conidial generation 16, tubes b and c, from which conidial generation 17, tubes b and c, were made, produced almost entirely acervuli. Of generation 17, tube b produced almost entirely perithecia, while c was practically identical with generation 16, tube c, showing chiefly acervuli.
- Plate X. *Glomerella cingulata* from Persea. Conidial generation 17 produced from 16, tube b, which was almost identical with tube 4. These cultures showed rather regular intergradations from tube 1, which chiefly produced perithecia, to tube 7, which produced acervuli almost entirely. Tubes all the same age.
- Plate XI. *Glomerella cingulata* from Persea. Conidial generation 17, tube b, showing mostly perithecia, and six subcultures from the same. All the cultures except the one at the extreme right showed a great predominance of acervuli, with but few perithecia, showing a reversion to the form in generation 16, tube b.
- Plate XII. *Glomerella cingulata* from Persea. Showing striking variations. Conidial generation 17. Tubes d, e, f, and g, all originated from generation 16, tube b. Compare Plate IX. Of generation 17, tubes d, e, and f show mostly perithecia; g has perithecia at the bottom of the culture and acervuli above. Of conidial generation 19, tube b shows mostly acervuli, while of generation 20, tube b produced mostly perithecia.

Plate XIII. *Glomerella cingulata* from *Persea*. Seven tubes from conidial generation 17, derived from generation 16, tube c, which produced chiefly acervuli. These cultures all produced, chiefly perithecia which were arranged in dense, scattered black masses, instead of being separate and evenly distributed, as in most cases of the preceding generations. Compare Plate IX.

Plate XIV. *Glomerella cingulata* from *Persea*. Two plates poured from conidial generation 9, tube a. Conidia were numerous at first in both plates, but were scattered, and no conspicuous acervuli seen. Only one colony, a, produced distinct and conspicuous acervuli. The rest of the colonies were chiefly perithecia. Compare Plate IX, tube 9 a.

Plate XV. *Glomerella cingulata* from *Persea*. Plates 10 days old made from crushed perithecia and ascospores. The irregular, scattered, large, dark bodies, a, are colonies of acervuli. The other colonies are chiefly perithecia. This strain of the fungus originated from a single conidium. A greater development of perithecia is observed along lines of contact between the conidial and perithecial colonies.

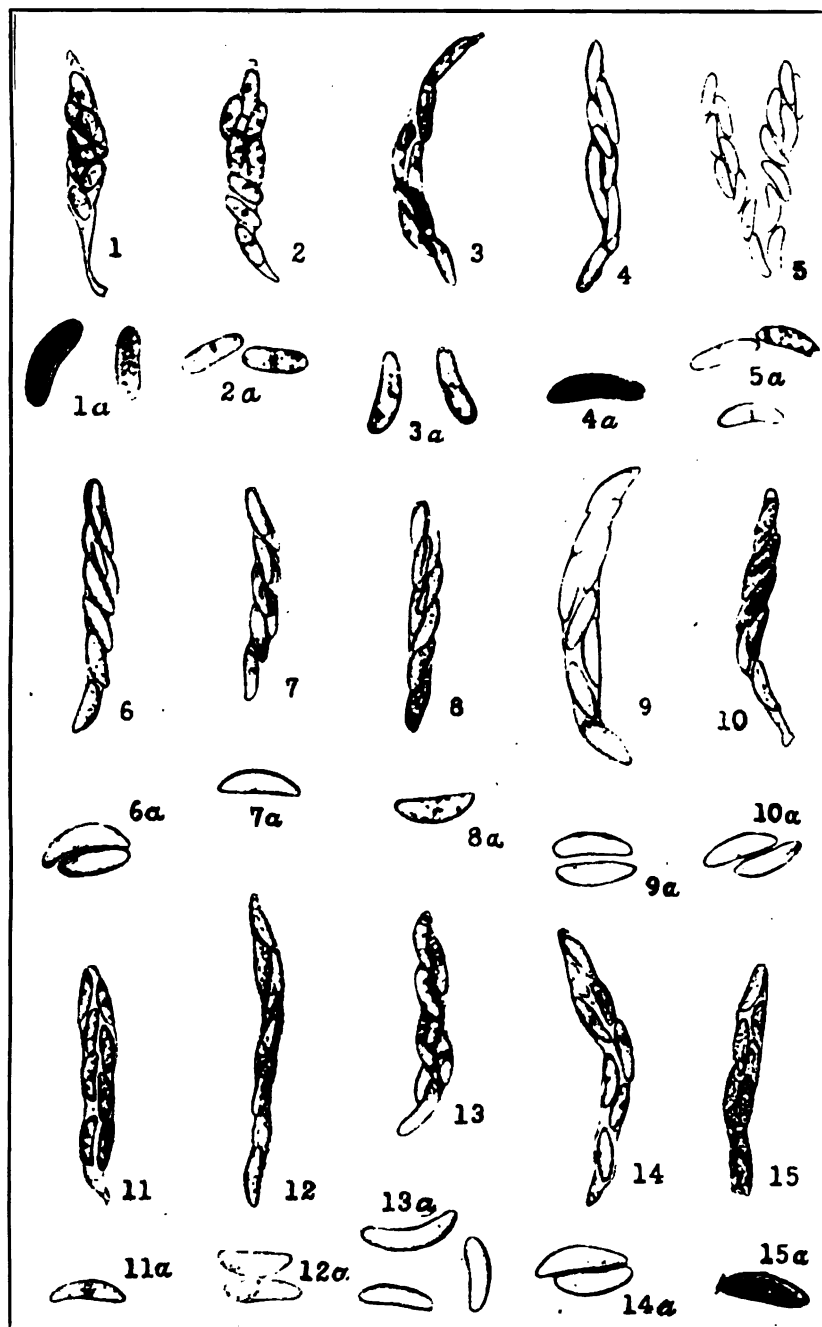
Plate XVI. Willow Twig apples inoculated with conidia of *Glomerella cingulata* from 4 different hosts. Figures 1 and 2 inoculated with conidia from an apple; figures 3 and 4, from a lemon; figures 5 and 6, from grapes; figures 7 and 8, from a fig. The strain of the fungus from the apple showed less virulence in this instance than that obtained from other hosts. All were inoculated at the same time, in the same manner, and kept under the same conditions.

Plate XVII. Eight figs 13 days after inoculation with conidia of *Glomerella cingulata* obtained from a rubber plant. The four upper fruits were inoculated by puncture; the four lower by surface application. All except two of those inoculated on the surface developed the common *Glomerella* rot of the fig.

Plate XVIII. Watermelon inoculated with conidia of *Glomerella cingulata* obtained from guava. The decayed area is practically covered with large acervuli.

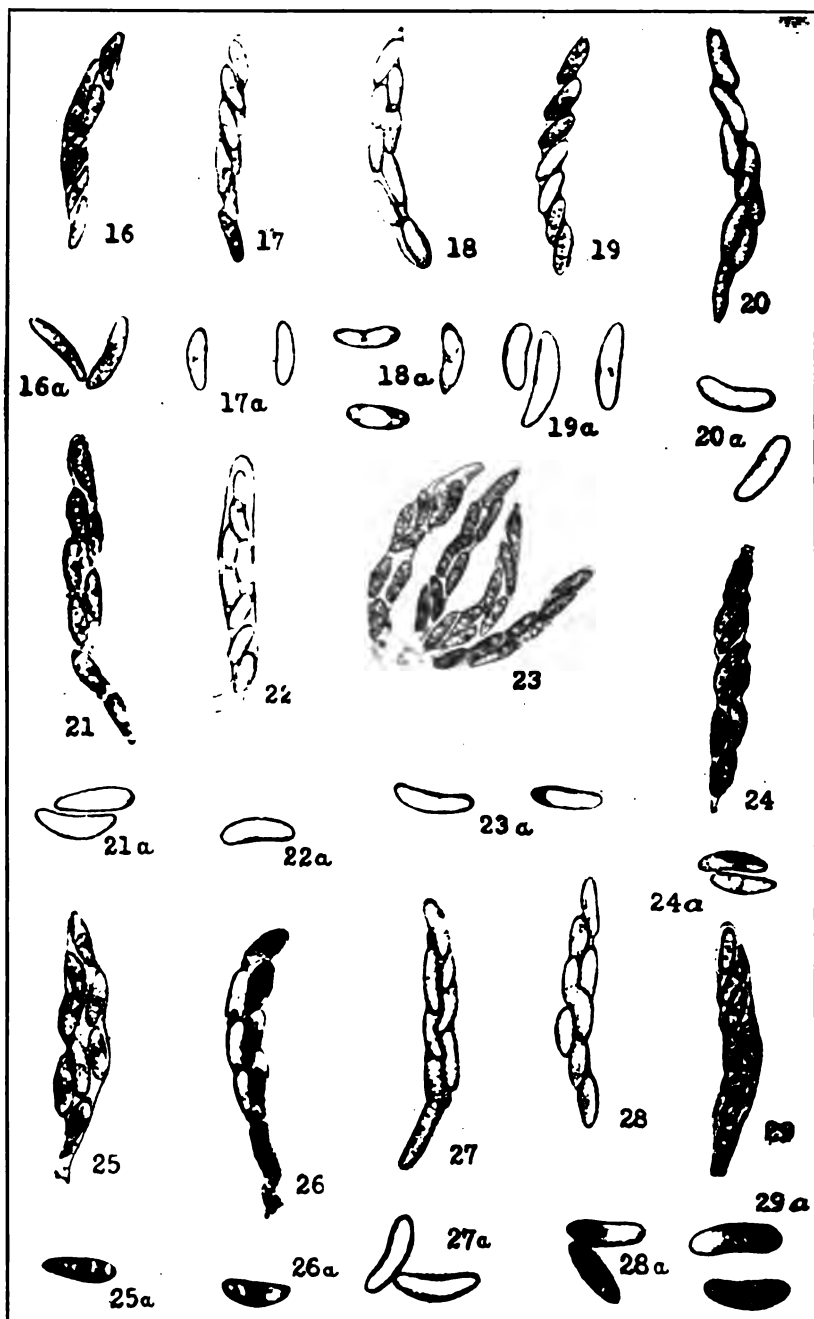
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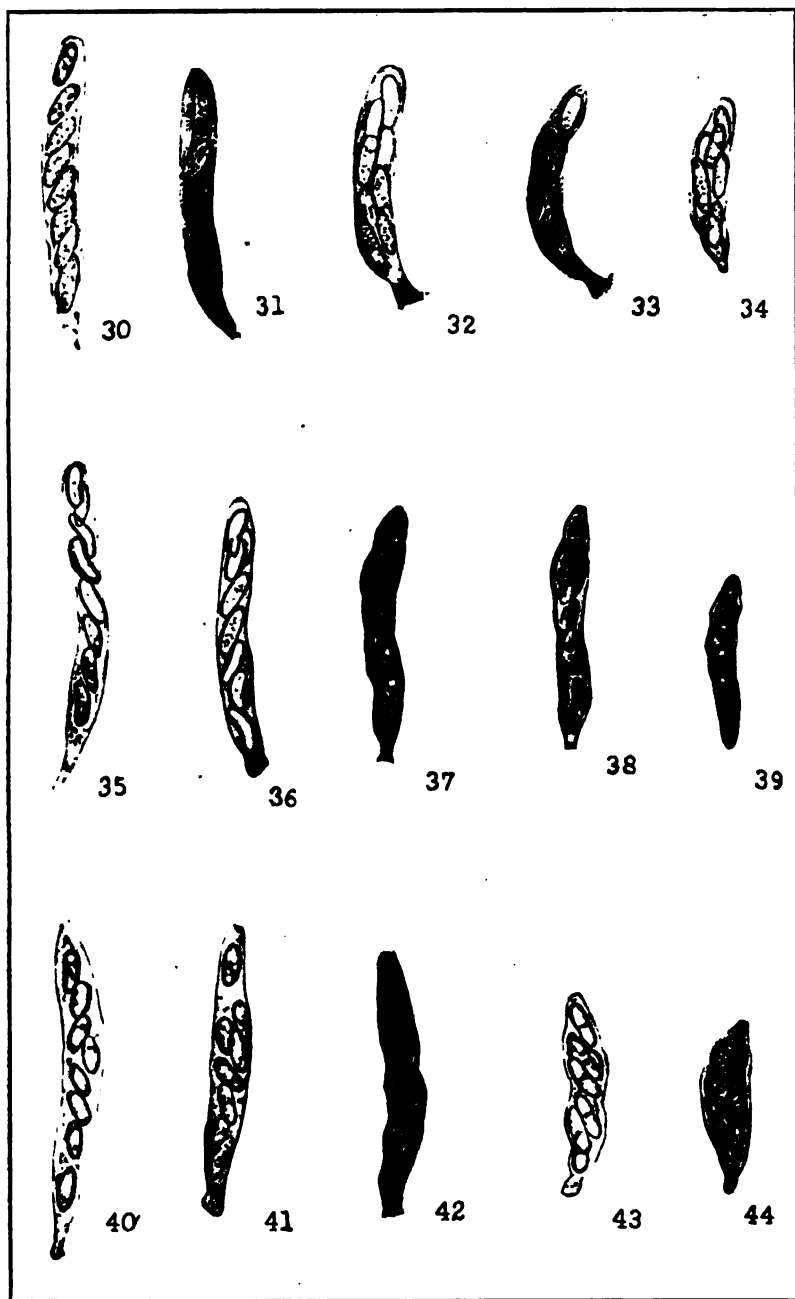
GLOMERELLA ASCI AND ASCOSPORES FROM VARIOUS HOSTS.

Figs. 1 and 2 from grape; 3, apple; 4, cranberry; 5, black raspberry; 6, pomelo; 7, lemon; 8, orange; 9, guava; 10, avocado; 11, loquat; 12, cotton; 13, bean; 14, coffee; 15, camellia. Asci $\times 450$, separate ascospores $\times 700$ diameters.



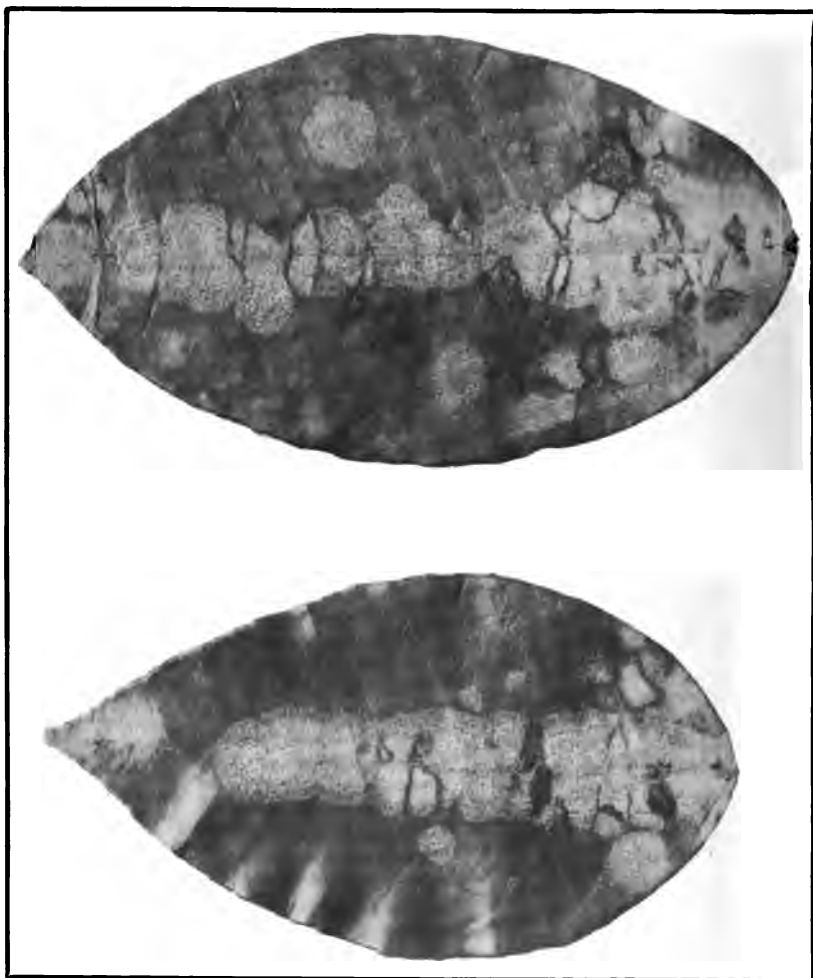
GLOMERELLA CINGULATA ASCI AND ASCOSPORES FROM DIFFERENT HOSTS.

Fig. 16 from tea; 17, privet; 18, rubber plant; 19, *Ficus longifolia*; 20, honey locust; 21, spiral flag; 22, *Curculigo*; 23, ebony; 24, chocolate; 25, *Pitcairnia*; 26, palm; 27, *Ginkgo*; 28, *Car-yota*; 29, fig. Asci $\times 450$, separate ascospores $\times 700$ diameters.

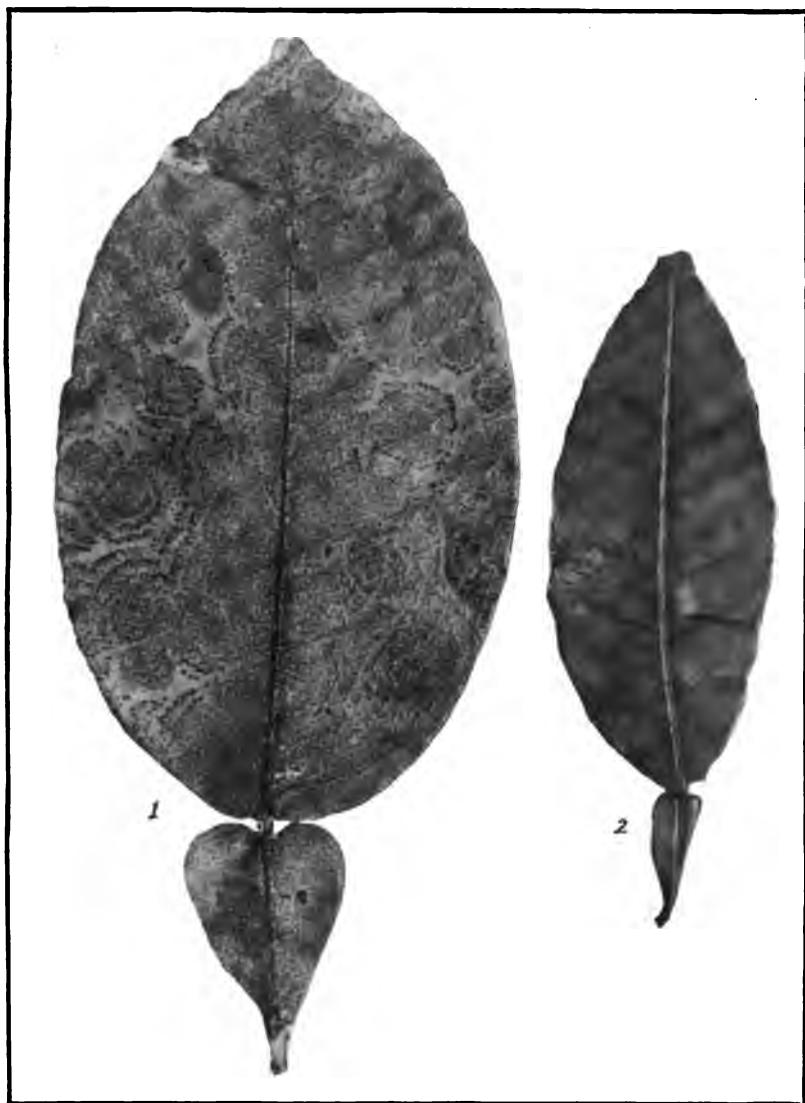


GLOMERELLA CINGULATA ASCI FROM THREE DIFFERENT HOSTS, SHOWING THE RANGE OF VARIATION IN EACH.

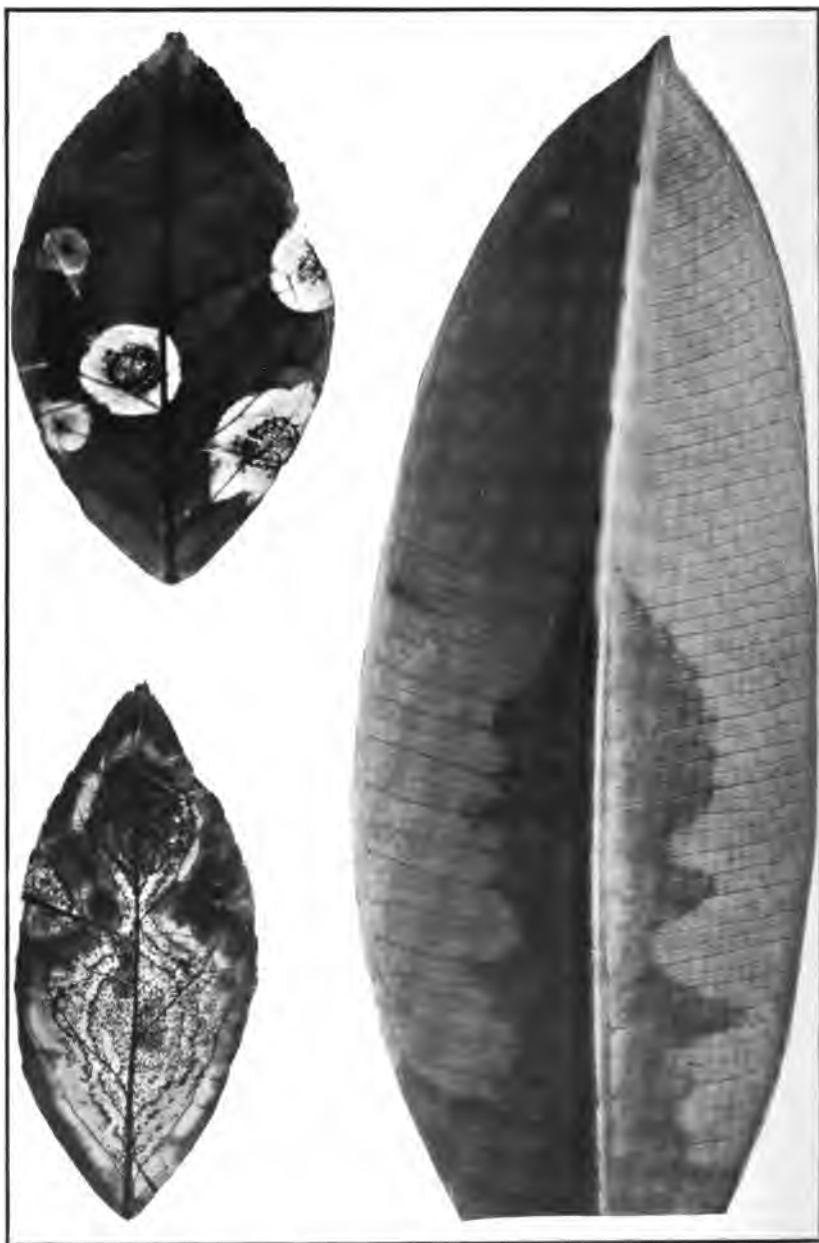
Figs. 30 to 34 from grape; 35 to 39, apple; 40 to 44, fig. All $\times 450$ diameters.



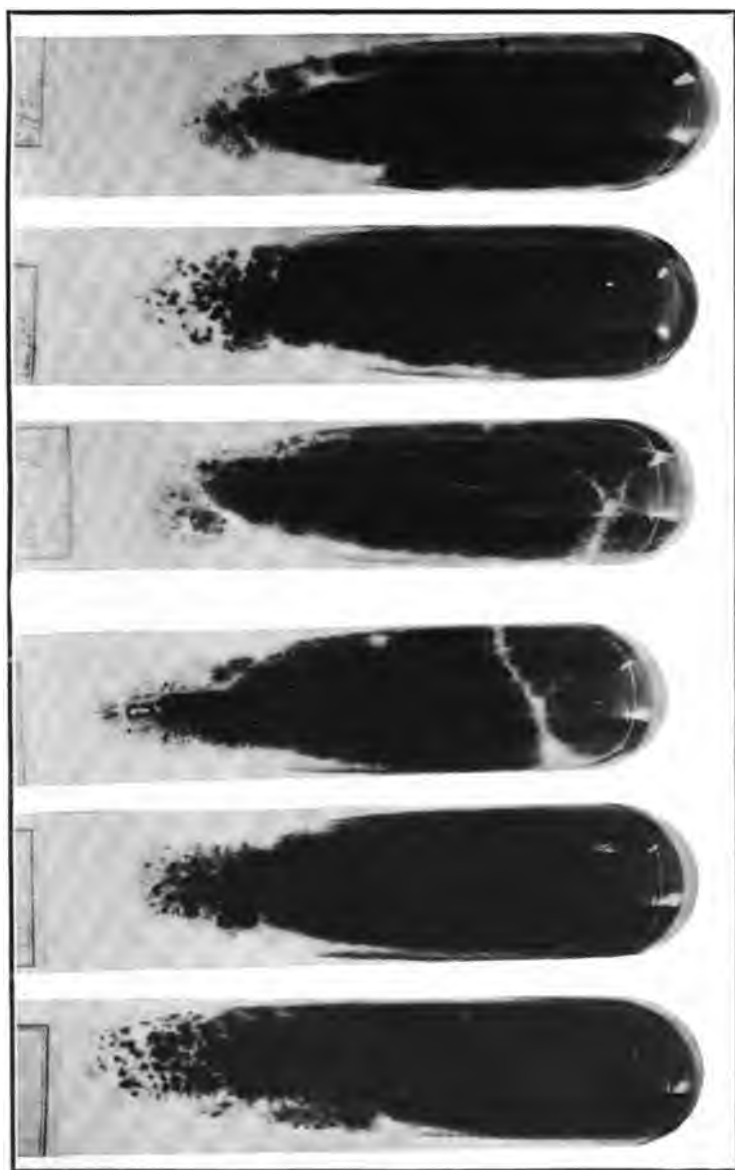
POMELO LEAVES, SHOWING DEVELOPMENT IN MOIST CHAMBER OF NUMEROUS COLONIES OF *GLOMERELLA CINGULATA* ON APPARENTLY HEALTHY LEAVES. ONE YEAR'S DIFFERENCE IN THE AGE OF THE LEAVES. THE COLONIES MOSTLY ORIGINATED FROM THE MIDRIB.



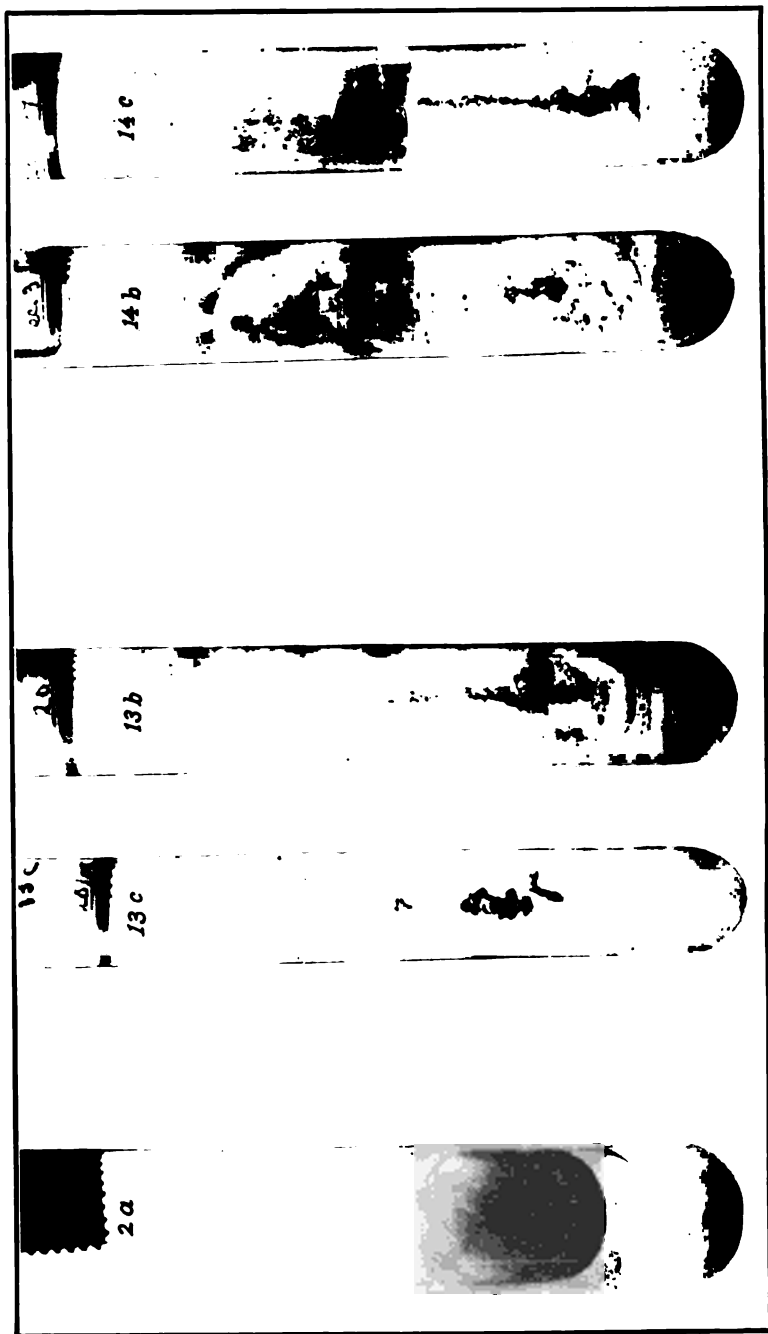
POMELO LEAVES, SHOWING (1) DEVELOPMENT OF COLONIES OF *GLOMERELLA CINGULATA* IN MOIST CHAMBER AND APPARENT LOCALIZATION OF NUMEROUS POINTS OF INFECTION; (2) THE SMALL LEAF ONE YEAR YOUNGER, FROM SAME PLANT TREATED IN THE SAME MANNER, APPARENTLY NOT INFECTED.



GLOMERELLA CINGULATA ON TWO ORANGE LEAVES, SHOWING DEVELOPMENT OF THE FUNGUS ON APPARENTLY HEALTHY LEAVES IN A MOIST CHAMBER AND LOCALIZATION OF THE COLONIES. THE RUBBER PLANT LEAF AT THE RIGHT SHOWS DEVELOPMENT OF THE FUNGUS PROCEEDING FROM THE PETIOLE ALONG THE MIDRIB.

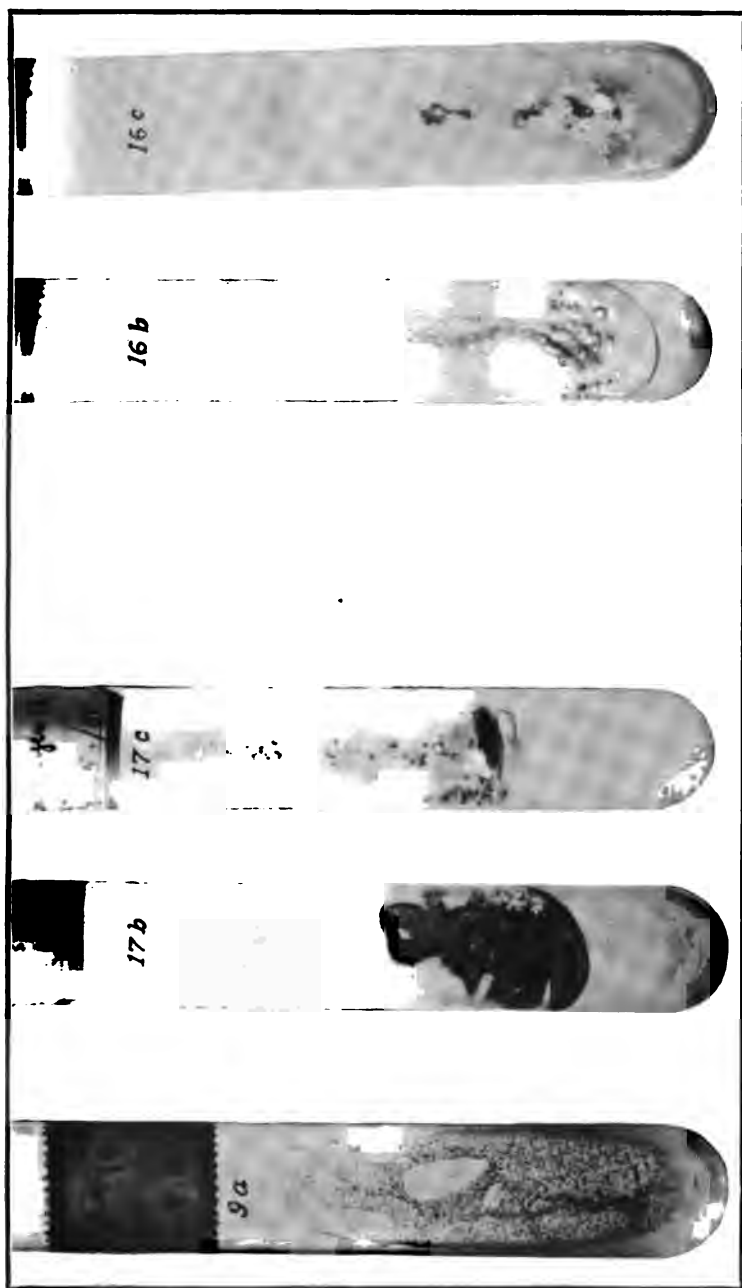


GLOMERELLA LINDEMUTHIANUM CULTURES FROM BEAN. SIX TUBES FROM CONIDIA FROM A SINGLE ACERVULUS, SHOWING THE UNIFORM CHARACTER OF THE CULTURES AND THE DARK MYCELIA PRODUCING ACERVULI ONLY.



GLOMERELLA CINGULATA CULTURES FROM PERSEA—I.

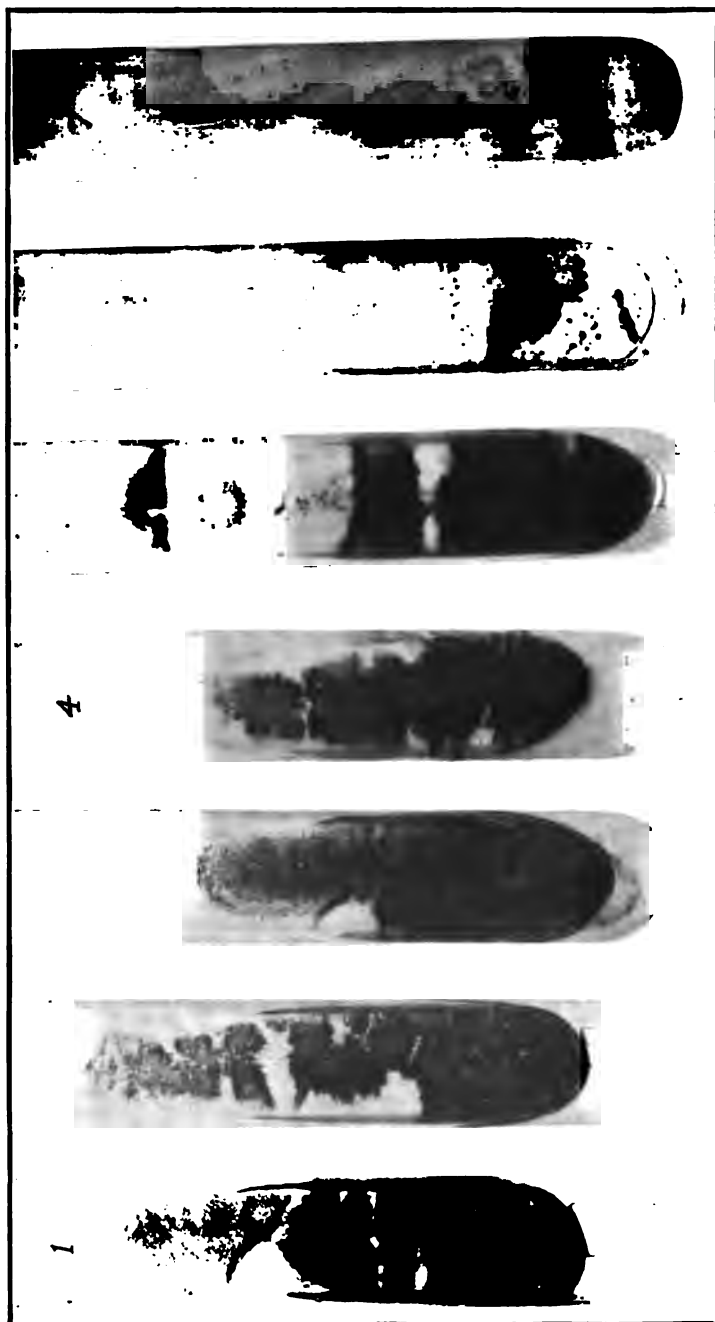
Ascomycete generation 2, tube *a*, showing the black perithecia thickly covering the surface. Conidial generation 13, tubes *b* and *c*, chiefly acervuli; and conidial generation 14, tubes *b* and *c*. *b* shows chiefly acervuli and conidia and *c* chiefly perithecia growing in masses along the line of inoculation.



GLOMERELLA CINGULATA CULTURES FROM PERSEA-II.

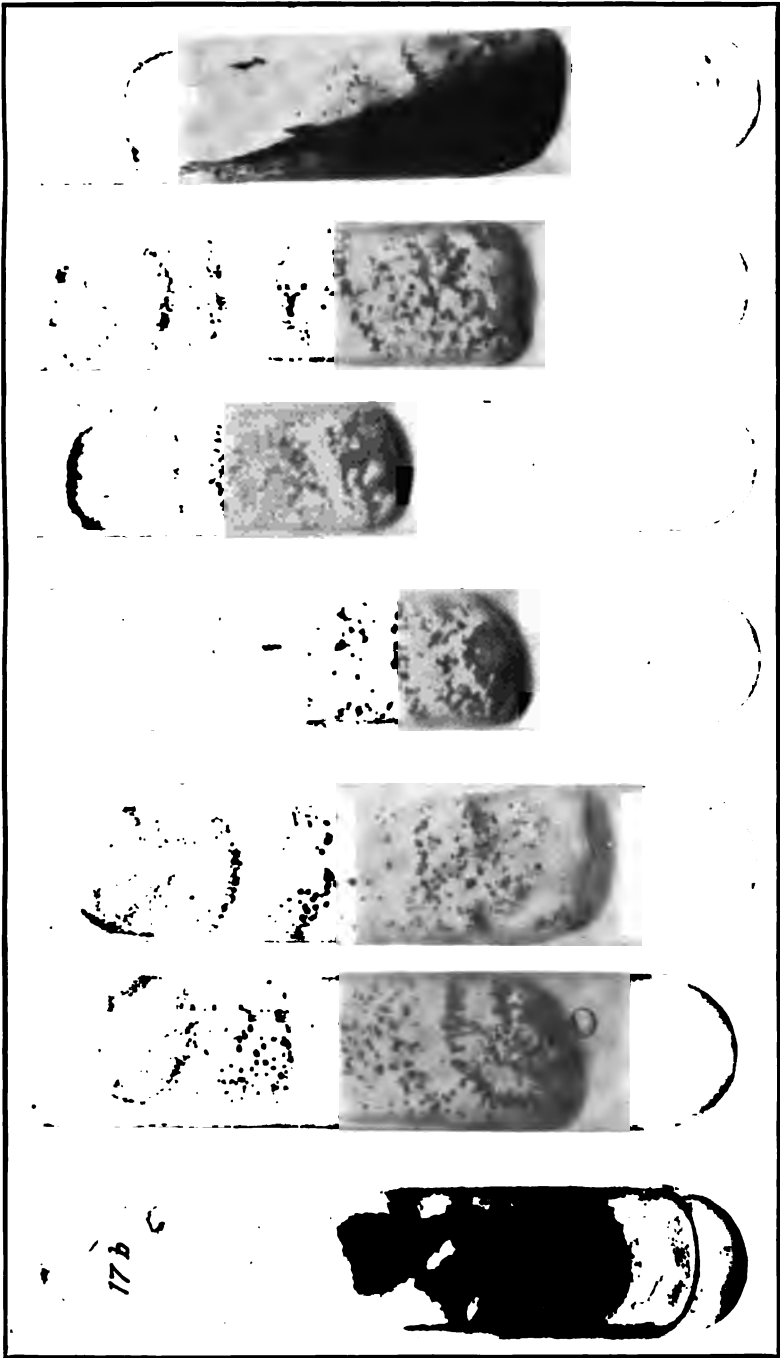
Conidial generation 9, tube *a*, showing numerous perithecia and a few acervuli near the bottom. Conidial generations 16 and 17, tubes *b* and *c*.

Sixteen *b* produced almost entirely acervuli; 17 *b* almost entirely perithecia, while 17 *c*, like 16 *c*, is chiefly acervuli.



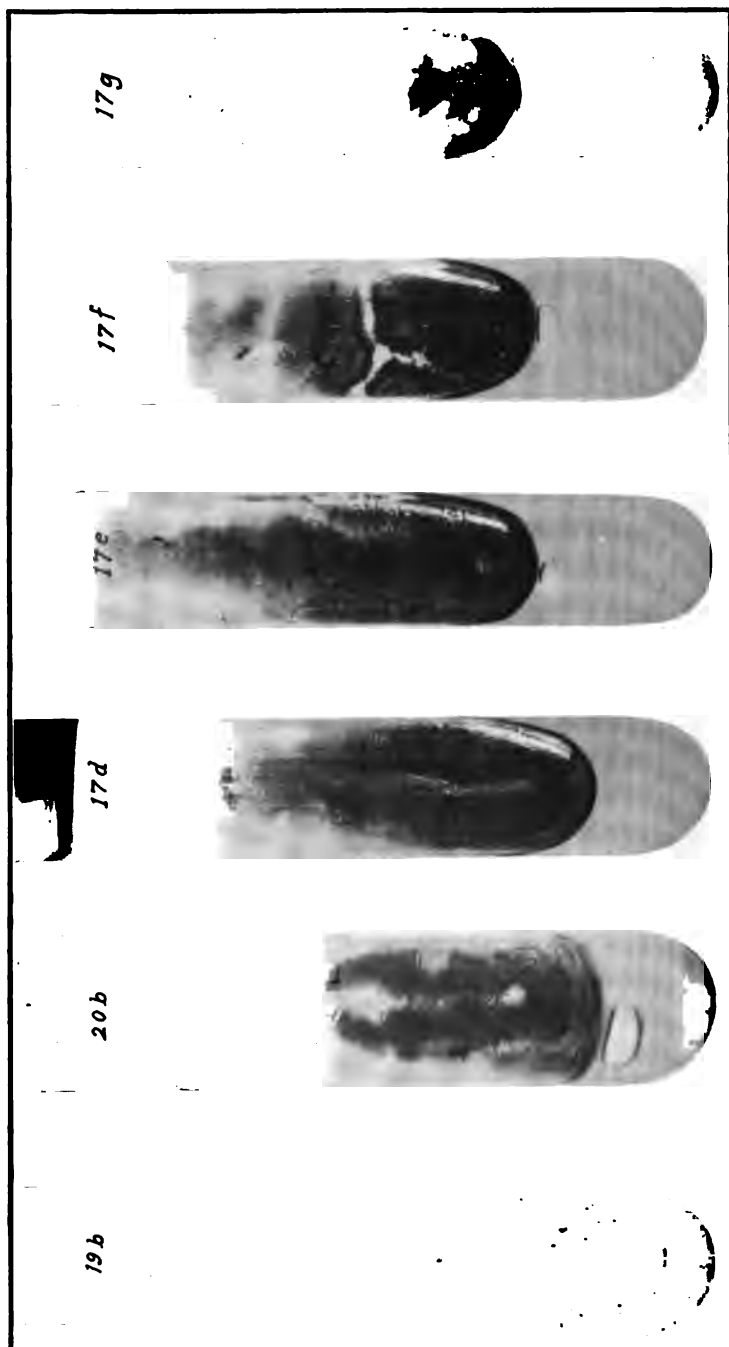
GLOMERELLA CINGULATA CULTURES FROM PERSEA—III.

Cnidial generation 17, consisting of subculture from generation 16, tube b, showing rather regular integrations from tube 1 containing chiefly perithecia to tube 7 containing chiefly acervuli. Compare Pl. XI.



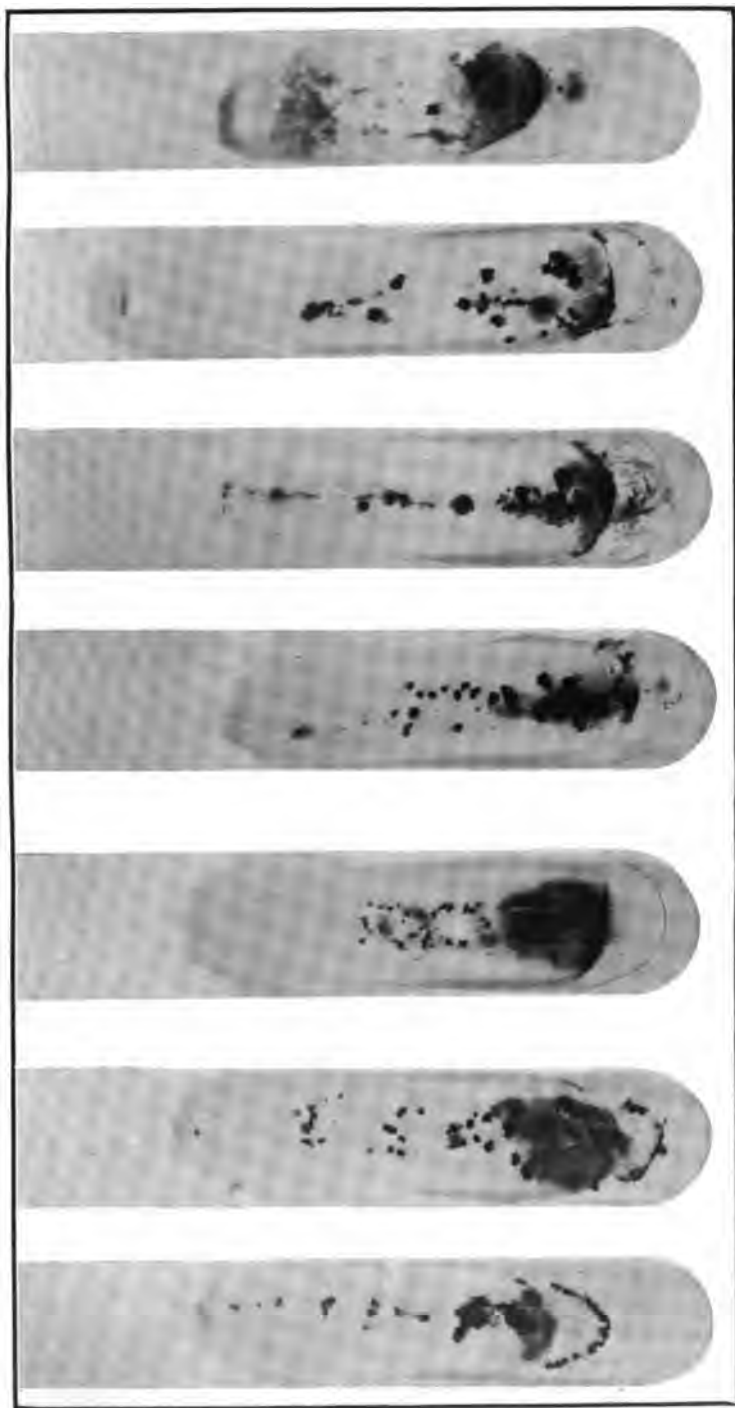
GLOMERELLA CINGULATA CULTURES FROM PERSEA—IV.

Conidial generation 17, tube b, showing mostly perithecia, and six subcultures from the same. These tubes, except the one at the extreme right, showed a great predominance of acervuli with few perithecia, as in 16 b. Compare Pl. X.



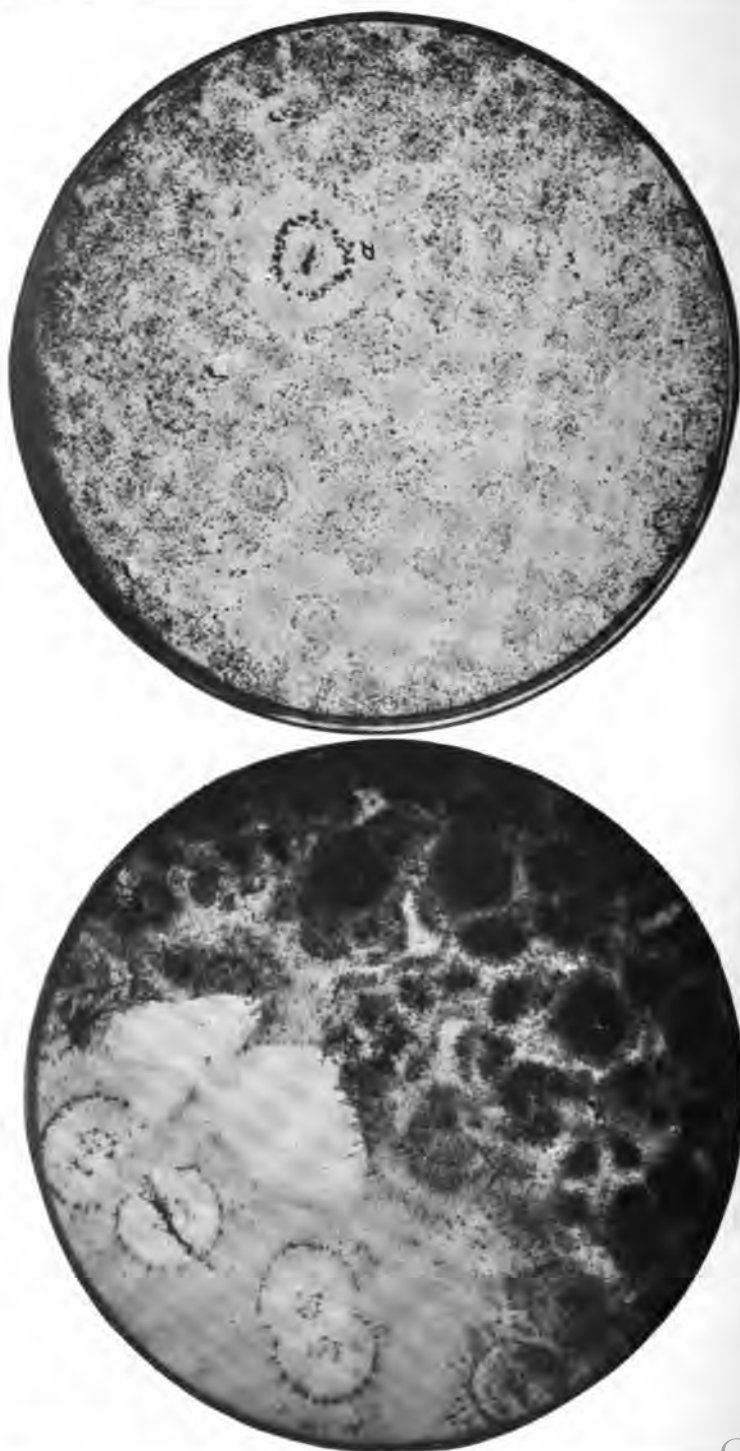
GLOMERELLA CINGULATA CULTURES FROM PERSEA—V, SHOWING STRIKING VARIATIONS.

Conidial generation 17, tubes *d*, *e*, *f*, and *g*, all from 16 *b*. Compare Plate IX. Tubes 17 *d*, *e*, and *f*, mostly perithecia; *g*, perithecia below and acervuli above; conidial generation 19, tube *b*, mostly acervuli; generation 20, tube *b*, mostly perithecia.



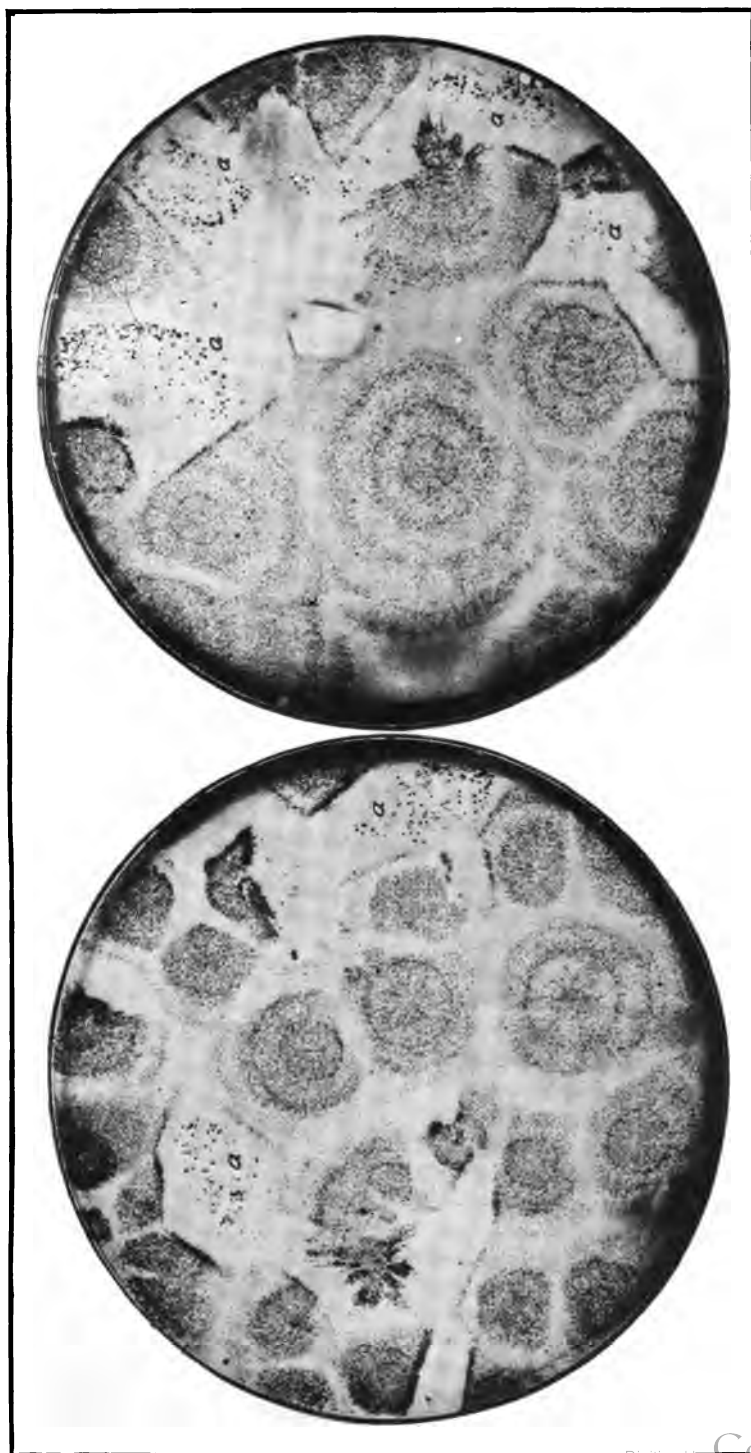
GLOMERELLA CINGULATA CULTURES FROM PERSEA—VI, SHOWING VARIATIONS.

Seven tubes of conidial generation 17, from generation 16, tube c, which produced chiefly acervuli. These tubes show chiefly perithecia in dark masses. Compare Pl. IX.



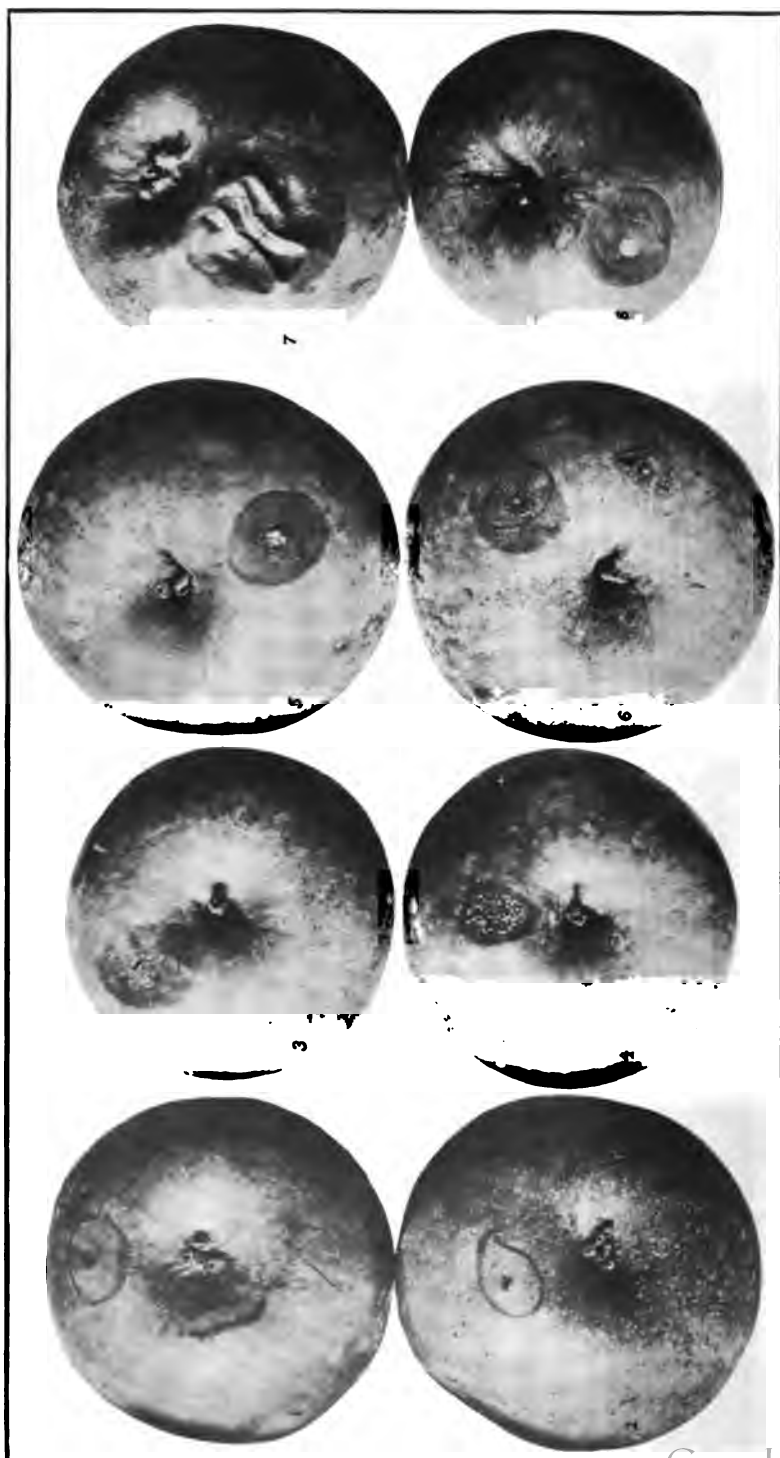
GLOMERELLA CINGULATA CULTURES FROM PERSEA-VII.

Two plates from confluent generation 9, tube a. Only one distinct colony, a, produced large overvull, the rest chiefly perithecia. Compare Plate IX, tube 9 a.



GLOMERELLA CINGULATA CULTURES FROM PERSEA—VIII. PLATES 10 DAYS OLD FROM CRUSHED PERITHECIA AND ASCOSPORES.

The irregular, scattered, large, dark spots, *a*, are colonies of *aecvuli*, the others perithecia. Note the greater development of perithecia at the lines of contact between these colonies and the perithecial colonies.



WILLOW TWIG APPLES INOCULATED WITH CONIDIA OF *GLOMERELLA CINGULATA* FROM DIFFERENT HOSTS.

Figs. 1 and 2, from apple; 3 and 4, from lemon; 5 and 6, from grape; 7 and 8, from fig.



FIGS 13 DAYS AFTER INOCULATION WITH CONIDIA OF *GLOMERALLA CINGULATA* FROM A RUBBER PLANT.

The four upper fruits were inoculated by puncture, the four lower by surface application. All except two of those inoculated on the surface developed rot.



**WATERMELON INOCULATED WITH CONIDIA OF *GLOMERELLA CINGULATA* FROM GUAVA.
THE DECAYED AREA IS PRACTICALLY COVERED WITH LARGE ACERVULI.**

Issued January 11, 1913.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 253.

B. T. GALLOWAY, *Chief of Bureau.*

THE KAOLIANGS:

A NEW GROUP OF GRAIN SORGHUMS.

BY

CARLETON R. BALL,

*Agronomist in Charge of Grain-Sorghum and
Broom-Corn Investigations.*



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¹ On July 1, 1912, the name of this office was changed from "Grain Investigations" to "Cereal Investigations."

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., April 27, 1912.

SIR: I have the honor to transmit herewith a manuscript entitled "The Kaoliangs: A New Group of Grain Sorghums," and to recommend that it be published as Bulletin No. 253 of the series of this Bureau. This bulletin was prepared by Mr. Carleton R. Ball, Agronomist in Charge of Grain-Sorghum and Broom-Corn Investigations in the Office of Grain Investigations, and has been submitted by Mr. Mark Alfred Carleton, Cerealist in Charge of Grain Investigations, with a view to its publication.

The kaoliangs comprise a new group of grain-producing sorghums from eastern Asia. During the past few years a large number of varieties and strains of this group have been introduced into the United States from China and Manchuria. Most of these introductions have been carefully tested for agronomic value in comparison with milos, kafirs, and durras. All of the varieties are drought resistant. Some of them are very early and therefore adapted to higher elevations and more northern latitudes than the members of other groups. The better sorts are now becoming distributed among farmers and it is desirable to publish a description of them and their adaptations and to point out the conditions under which they are most likely to prove of value.

In dealing with this new group it was necessary to make a very comprehensive varietal study in connection with the work of agronomic improvement. In order to make permanent the records concerning the whole series of about fifty introductions, a description of each is given under the serial number used to designate it by the Office of Foreign Seed and Plant Introduction of this Bureau.

Thanks are due to the many explorers, missionaries, consular officers, and others who have assisted in procuring the seeds of these varieties. Full acknowledgment of their assistance has been made in connection with the description of the various introductions. The author wishes also to express his obligation to Miss M. E. Holland for

assistance in determining the colors of the seeds and glumes and to Mr. B. E. Rothgeb and Mr. Karl H. Townsend for assistance in measuring plants, leaves, panicles, and seeds.

Figures 1, 2, 3, 4, 5, 6, 7, and 13 are from photographs made or obtained in China by Mr. Frank N. Meyer, Agricultural Explorer of this Bureau.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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THE KAOLIANGS: A NEW GROUP OF GRAIN SORGHUMS.

INTRODUCTION.

The kaoliangs comprise a group of grain-producing sorghums only recently introduced into cultivation and entirely new to the literature of this country. For about 13 years various agencies employed by or cooperating with the United States Department of Agriculture have been forwarding samples of kaoliang seed. These seeds have been sown at various points and the resulting crops studied from the two standpoints of relationship and value. Many data have been accumulated. Some of the varieties have been found to be of agronomic importance in parts of the United States. Since they have now become the property of both experimenters and farmers, it is desirable to present all available data on the group. There follows a brief discussion of the origin, culture, and use of the kaoliangs in their native home and a full description of the important varieties and their adaptations in this country. To this discussion is appended a description of all introductions made, so far as the records are available.

KAOLIANGS IN EASTERN ASIA.

With the exception of a single variety of sorgo,¹ which is grown locally on Tsungming Island in the mouth of the Yangtze River and occasionally on the adjacent mainland, the kaoliangs are the only sorghums found in eastern Asia, including the Chinese Empire, Japan, and Siberia.

NAMES.

The Chinese name for this group of plants is "kao-liang," meaning, literally, tall millet and pronounced kōw-lī-ang. This has been written in other similar forms, as "kauliang," "kaulien," "gaolan," "gaolien," "goolan," etc. These may represent slight differences in pronunciation by different Chinese or they may be merely the different attempts of Americans to reproduce phonetically the Chinese name.

Among the names applied to kaoliang by Europeans in the East are "tall millet," "great millet," "large millet," "giant millet,"

¹ Ball, Carleton R. The History and Distribution of Sorghum. Bulletin 175, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1910, pp. 24-25, 32-33, and fig. 9.

"false millet," and "Barbados millet." Most of these names are used to distinguish it from the smaller species of millet which are also commonly cultivated throughout China and in other parts of Asia as well. These species are *Panicum miliaceum* (proso) and *Chaetochloa* (*Setaria*) *italica* (foxtail millet). The use of the term "Barbados millet" by foreigners in China was noted previous to 1866 by Doolittle,¹ who says:

The so-called Chinese sugar cane or sorghum is grown very extensively in northern China and is known among foreigners as a kind of millet—the Barbados millet. The Chinese name for it is kaoliang.

The name probably arose from the resemblance of certain kaoliangs to that kafir variety grown in Barbados and other islands of the West Indies with which some English residents of China were probably somewhat familiar.

It should be noted here that varieties of kaoliangs have been frequently written about and their seeds sent to this country under the name "glutinous millet." This is an error that has probably arisen through a misapprehension of the species really called "glutinous millet" by the Chinese, probably *Panicum miliaceum*. The venerable Dr. S. P. Barchet, of Shanghai, stated the matter tersely in conversation with the writer, as follows: "The large millet of Shantung Province is not glutinous; the glutinous millets are not sorghums." So far as studied, the seeds of kaoliangs, in common with those of all other groups of sorghums, are comparable to maize in chemical composition and are never gluten bearing, as are the seeds of wheat, for example.

In Japan the general term applied to sorghum is "morokoshi," according to the statements made by Dr. Sawano,² of the imperial experiment station at Tokyo, in transmitting three samples of the seed, viz, Agrostology Nos. 1584 to 1586. These three were further designated as "sato-morokoshi" or sugar sorghum; "hoki-morokoshi" or broom sorghum, and "kibi" or "to-kibi," millet or tall millet, respectively. For his full statements, consult these numbers and also Agrostology No. 1576 in the descriptive list of introductions. Rein³ uses the term "morokoshi" and also "taka-kibi," or high millet.

ORIGIN.

It is probable that this group of sorghums was originally brought into China from India. There is evidence,⁴ however, that this introduction took place many centuries ago and that the forms as we now find them in China and Manchuria probably vary considerably from

¹ Doolittle, Justus. *Social Life of the Chinese*, 1866, p. 43; revised edition, by E. P. Hood, 1908, p. 25.

² Sawano, J., in letter of April 23, 1903.

³ Rein, J. J. *Industries of Japan*, 1889, p. 51.

⁴ Ball, op. cit., pp. 11, 24.

the original importations. Among several hundred varieties of sorghum imported into the United States from India and carefully studied variety, no duplicates of the Chinese kaoliangs have been found. This fact is not surprising if 10 or 15 centuries have elapsed since their translocation from India to China took place.

DISTRIBUTION.

The Chinese Empire (Pl. I) has an extreme breadth from south to north of about 2,300 miles, or about 2,500 miles if the island of Hainan is included. The southern boundaries of the provinces of Yunnan and Kwangsi are approximately 21° north latitude, while the northern extremities of Mongolia and Heilungkiang Province in Manchuria reach 54° north latitude. The length of the empire from east to west is, roughly, 3,200 miles. The most eastern point of Kirin Province, Manchuria, touches the meridian of 135° east longitude, while the most western extremity of Chinese Turkestan has less than 74° of east longitude.

In general, the topography of the empire is a series of elevated mountain ranges and plateaus in the central and western parts, declining gradually eastward to a broad and fertile alluvial plain of low elevation. This plain has such a gentle gradient as to make part of it subject at times to disastrous overflow and consequent famine.

From the reports of explorers, missionaries, and others it is known that the kaoliangs are grown more or less extensively over most of the eastern half of the empire.

In China proper they are found from Yunnan, which is the most southwestern province and adjoins Tibet on the southeast, to Chihli in the north and thence south to Shantung and Chekiang. They appear to be found only rarely or not at all in the southeastern alluvial provinces from Fukien and Kiangsi on the east to Kwangtung and Kwangsi on the southwest. These provinces comprise part of the great rice-growing area of China. In general the kaoliangs become increasingly important westward in the piedmont areas up to prohibitive elevations and northward with increased latitude and shorter seasons.

Much has been written about the kaoliangs in North China and Manchuria, but very little about their occurrence in western China. The following note by Wilson,¹ who had then traveled five years in the provinces of Yunnan, Szechwan, and Hupeh, in southwestern China, will be of interest. He says, under the heading "False millet":

This is the kaoliang of the Chinese, which is largely used in China for making wine. It is cultivated generally throughout central and western China, but not so extensively as in other parts of China, notably Manchuria. The largest areas I noted

¹ Wilson, E. H. Leaves from My Chinese Notebook. *Gardeners' Chronicle*, September, 1905, vol. 38, p. 246.

were on the plateaux of Yunnan, the plain of Chentu¹ and the fluvial areas of the Min and Fo Rivers. Its altitudinal limit is the same as that of maize and, like this latter, it is always a summer crop.

It is in the province of Manchuria, however, that these crops are most abundantly grown and become highly important staples on the farm. They are found commonly in Chosen (Korea) also, and to a lesser extent in Japan. Just to what extent they are grown in Siberia, above the borders of Manchuria and Chosen (Korea), is not known. Seed has been obtained from Usuri Province, northeast of Chosen, and also (S. P. I. No. 939) from Nertchinsk in Trans-Baikalia, at 51° north latitude. It is not stated, however, in either case whether it was grown in these provinces or merely imported as a cereal.

Kaoliang was prominently mentioned in Manchuria under the name "tall millet" during the progress of the Russo-Japanese War. This fact developed from the frequent maneuvering of infantry, and even of cavalry also, under cover of the shelter afforded by fields of this tall-growing crop.

CULTURE.

While the native methods of growing the kaoliang crop would seem rather crude to the American farmer, accustomed to the use of improved machinery, they are really quite thoroughly systematized. So far as the practices obtaining in Manchuria are concerned, the writer can do no better than quote from a paper by the consular officer of the United States at Newchwang. Manchuria is the banner kaoliang-producing region and Newchwang is not only situated in the region of production but is the port through which most of the Manchurian exports pass. The report of Consul General Sammons² is as follows:

Holcus sorghum, or tall millet.—*Holcus sorghum*, or tall or giant millet, of which the Chinese name is kaoliang, is planted in drills in the deep, rich loam throughout Manchuria. The seed is sown by hand and is then covered with manure. Stone rollers are then passed over the drills. When the shoots are 2 or 3 inches high they are thinned to about 18 inches apart. The weeds are carefully destroyed, and, except the earthing up of the roots or "hilling" the plants, as in caring for Indian corn in the United States, no further attention is required until harvest time in September. Should there be heavy rains in May the plants may be greatly damaged by roots losing their hold on the soil, resulting in the plant being blown over. Too much rain or a lack of rain may prevent the seed from ripening; but as a rule, as is the case this season, a good crop is secured.

During the early part of September, the stalks, having reached a height of from 8 to 10 feet, and the heads having turned purple—caused by the small, dark purple cases which contain the grain—they are cut down near the roots. This usually takes place toward the close of the month. The process of thrashing consists of cutting off the

¹ Chentu (Chengtú) and the Min and Fo (Fu) rivers are in Szechwan.

² Sammons, Thomas. Manchuria: Manufactures and Agriculture. Monthly Consular and Trade Reports, No. 301, October, 1905, pp. 52-54.

heads of the stalks, spreading them on the floor, and thrashing them with a stone roller drawn by some domestic animal. This is completed in about four hours. The grain is then passed through a winnowing machine or tossed up in the air, after being separated from the empty heads, which are used either for fuel or in the manufacture of brooms. The now cleaned, but unhusked, grain is put in sacks and is ready for the market, being sold for fodder. To be fit for human consumption it must still pass through the process of husking, which consists of placing the grain on a circular stone floor, passing a circular stone roller over it, which crushes the husks, and separating the grain from the husks.

It is estimated that 8 pounds of the seed will sow an acre of ground and that the yield in grain will be half a ton if the crop is good. There is in Manchuria practically an inexhaustible supply of giant millet stalks, but these stalks are by no means a valueless or useless quantity. It is estimated that the product of an acre (6 Chinese mu) will weigh from $1\frac{1}{4}$ to $1\frac{1}{2}$ tons of 2,000 pounds. The value of the dry stalks is approximately \$5 gold per ton. The stalks are usually sold in bundles of about 10 stalks. In the Chinese method of reckoning there are about 75 bundles to each mu, and 100 of these bundles to 320 catties (a catty is equal to $1\frac{1}{2}$ pounds). The native price is \$1 to \$2.50 (Mexican) to the 100 bundles, equivalent to 50 cents to \$1.25 gold.

Mr. Frank N. Meyer, Agricultural Explorer of this Bureau, who has traveled widely in Manchuria and North China, has kindly furnished the following original account of the culture of kaoliang in those areas:

It seems that sorghum was introduced into China from India in the second century of our calendar. It soon spread until now it has become the staple crop of the North, and it has developed a great number of varieties. The shortest variety I ever saw was found growing along the coast of Shantung and was barely three feet in height, with very dense heads of seeds, while on some of the low, rich land near Tientsin varieties may be found that tower 20 feet in height and often have loose, spreading heads. Then there are white, light-brown, and dark-brown seeded varieties, and forms with white, brown, and black hulls; erect-headed ones, drooping ones, and hybrids between all of them. [See fig. 1.] In some fields, where the grower has not been very careful about the selection of his seeds, one might easily find 30 or 40 different forms in an hour's time, some even ripening fully a fortnight later than others, which can be explained by the fact that the Chinese only cut those heads that are ripe, leaving the others to ripen later on. Later, the seeds of both early and late sorts are often mixed together again, and the next year's crop is still worse in irregularity of ripening.

The method of growing the kaoliang in North China is as follows: The soil on which the grain is going to be planted has been plowed in the autumn, has lain rough and unbroken during the winter, and is manured and plowed in the spring. During the month of May the seeds which, by the way, often have been soaked in water overnight, are sown in rows in hills 2 to 3 feet apart, and the rows always run north and south. A few days later the young plants appear above the ground. They do not make much growth until the first summer rains, which usually begin in the latter part of June, although also often not until early July. The fields are regularly hoed and cultivated, even if the plants do not make much progress. When once the rains have started, however, the young sorghum shoots up with an amazing quickness and can almost be seen to grow.

As soon as the plants are a foot or so high, the hills are thinned and generally only one plant is left. By about the middle of August the kaoliang has headed and when the seeds have set well a few weeks later, one may see in large fields hundreds of

workingmen pulling off the leaves from the plants, leaving only a few at the top. The Chinese claim that if they did not do this the grain would not ripen and the soil would not dry sufficiently to keep the plants healthy. Whatever truth there may be in this I do not know, but the fact is that these leaves are most carefully dried, packed

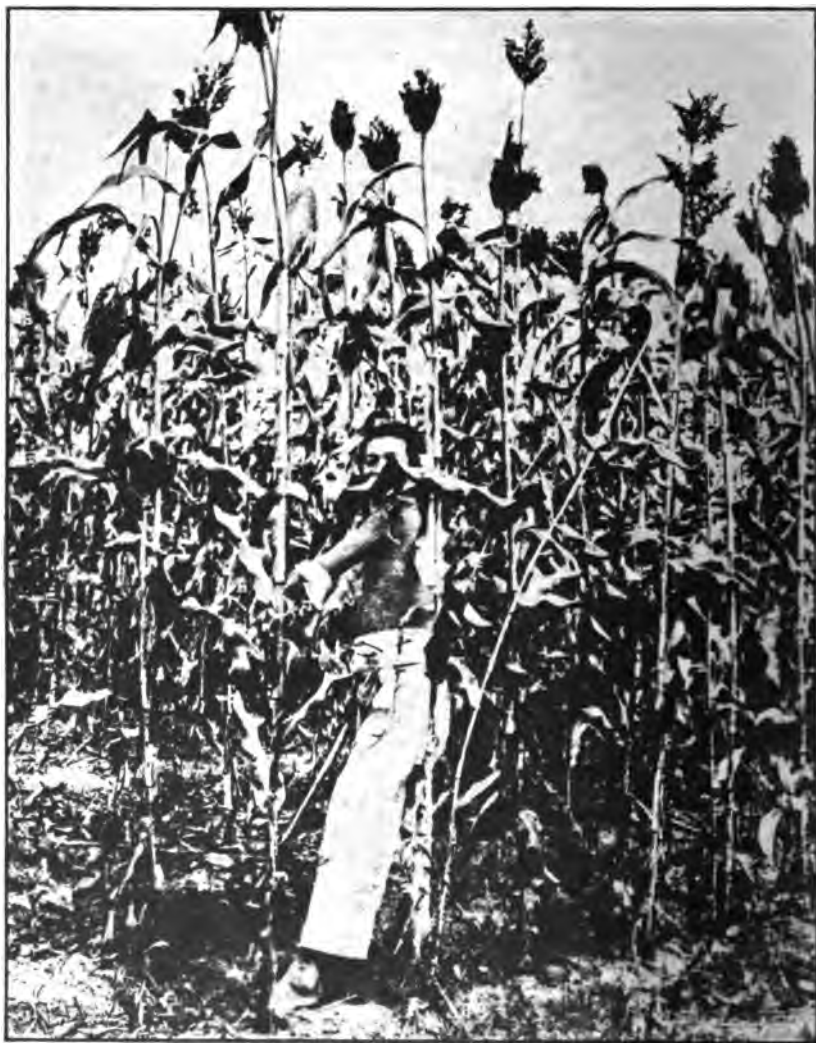


FIG. 1.—Field of kaoliang 10 feet high, in the vicinity of Harbin, Manchuria. (Photographed by Frank N. Meyer.)

into bundles, and kept as a winter food for the domestic animals. In a country without meadows, like China, these leaves take the place of hay.

When the seeds are at last sufficiently ripe, armies of men turn out again in the fields, and either cut the whole plants down and let them dry in sheaves, which method they use in the larger fields of Manchuria [see figs. 2 and 3], or, where the population is

dense and the fields smaller, the people cut off the heads first and store them away in safety, for there is much crop robbing in China. Later on they come back and cut the stalks down.

These harvested heads are spread out every day in the sun, in the yards, on matting, etc. When sufficiently dry, they are spread out again on a clay thrashing floor, and stone rollers [see fig. 4] hitched to horses, mules, donkeys, old men, women, or boys, are dragged over them. In this primitive way the seeds are thrashed out and later on winnowed, all by hand labor, and, when clean, are stored away in earthen jars, in baskets smeared over with clay, and in sacks. They form a very important item in the agricultural productions of Manchuria and North China.

The method of culture employed on Tsungming Island in the mouth of the Yangtze River, Kiangsu Province, China, is briefly



FIG. 2.—Hauling the kaoliang crop from the field on a two-wheeled cart, Harbin, Manchuria. (Photographed by Frank N. Meyer.)

given by Dr. S. P. Barchet,¹ interpreter at the American consulate, Shanghai, in transmitting the seed of two varieties, S. P. I. Nos. 22911 and 22912. He writes:

The white variety (S. P. I. No. 22912) is considered inferior to the red (S. P. I. No. 22911, Brown), though planted in the same way. It is planted in richly manured land, in rows 6 inches wide covered lightly with half an inch of earth. If plants come up too thick or crowded, the plants which should be removed are not pulled, but cut off with a sharp knife, so as not to disturb the roots of neighboring plants.

In Japan, as noted, the sorghum plant is not widely distributed and it is only sparingly cultivated in the localities where it has been introduced. Rein² states:

Guinea corn or Durrah, Japanese morokoshi (*Sorghum vulgare*, Pers[e]; *Holcus sorghum*, L.), called also taka-kibi (high millet), is of only small importance for Japan.

¹ Seeds and Plants Imported during the Period from April 1 to June 30, 1908. Bulletin 142, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1909, pp. 42-43.

² Rein, J. J. Industries of Japan, 1889, p. 51.

This grain is seldom found except along the borders of fields, encircling them in a furrow, and even this but rarely. It is raised in April, in a seed bed. Later, having attained a height of about 15 cm., it is transplanted at intervals of from 25 to 30 cm. It is harvested in September. The same holds good for the long-panicled form, the broom corn, so often grown in northern Italy, and of whose panicles brooms are also made in eastern Asia.

Consul General Bellows,¹ of Yokohama, in transmitting the seed of *Agrostology* No. 1576, says:

I have the honor to transmit a package of Japanese sorghum seed of the kind known as "morokoshi kibi." Messrs. L. Boehmer & Co., horticulturists, of Yokohama, who have furnished this seed without charge, inform me that this sorghum "is of very little importance in Japan, being generally planted along the borders of fields only, in order to protect the field crops against winds, etc. In some parts of the country where rice



FIG. 3.—Field of kaoliang curing in the shock, Harbin, Manchuria. (Photographed by Frank N. Meyer.

and other cereals do not grow sorghum is to a certain extent cultivated as a field crop. It is sown in April in seed beds and later transplanted at intervals of 8 or 10 inches."

Of the sato-morokoshi, or sugar sorghum (*Agrostology* No. 1584), Dr. Sawano² says:

This plant was introduced to this country from China about 28 years ago. For many years we tried to prepare sugar from it in many localities, but with poor success, on account of climatic and other circumstances. At the present time it was difficult to obtain even the small quantity sent.

The 28-year period mentioned by Sawano dates almost exactly from the publication of Collins's³ paper on the Chinese sorgo, which

¹ E. C. Bellows, in letter of March 6, 1903.

² Letter from J. Sawano, April 23, 1903.

³ Collins, Varnum D. Sorgo, or the Northern Chinese Sugar Cane. *Journal of North China Branch, Royal Asiatic Society*, n. s., vol. 2, December, 1865, p. 91.

doubtless led the Japanese to investigate the saccharine variety of China. Be that as it may, the sample sent was not the Chinese sorgo, but a Brown kaoliang, different from the other (No. 1586) which accompanied it.

Of the tall millet, or to-kibi, Sawano says:

It is generally planted along the boundary of a farm plat as a wind shelter for another principal summer crop. Its cultivation is very easy, and, indeed, the farmer does not pay much attention to it. In May or June the seeds are sown in one or two rows. It is harvested about October or November, when the heads turn yellowish in color.

USES.

The primary use of the kaoliang crop throughout most of the region where it is grown is for human food and the feeding of farm animals.



FIG. 4.—Thrashing kaoliang seed from the harvested heads by means of stone rollers drawn by horses or mules, near Harbin, Manchuria. (Photographed by Frank N. Meyer.)

It has, however, a great many secondary uses, due to the ingenuity and thriftiness of the Chinese in matters of economic detail. Its importance to the people of Manchuria and the uses to which they put it are well shown in the following quotation from Consul General Sammons,¹ of Newchwang:

The giant millet is no doubt the most valuable product of Manchuria to the natives. It is the staple food—that is, the seed—of the people, and is fed likewise to the beasts of burden. The seed is also used in distilling spirits or *sanshu*. Practically all of the giant millet is consumed in the country where it is raised in such great abundance. The stalks are not only used for fuel in winter, but in making mats. These are manufactured by hand from the outer leaves. Compound or yard fences [fig. 5] are made from the stalks. They also enter into house building and in constructing small bridges. Even the roots are used. In the spring when the fields are plowed the

¹ Sammons, *op. cit.*, pp. 53-54.

roots are saved and burned for fuel. * * * The empty heads are used either for fuel or in the manufacture of brooms.

The missionary previously mentioned, Mr. Doolittle, writing of the native life and customs in Fukien Province in 1866, says,¹ concerning the uses of kaoliang by the people of northern China:

They make a coarse kind of bread from the flour of the seed of the kaoliang, eaten principally by the poorer classes. The best kind of Chinese whisky, often called Chinese wine, is distilled from the seeds. The stalks are used for fuel, for lathing in the partitions of houses, for slight and temporary fences, etc. Numerous and



Fig. 5.—Kaoliang stalks used as a fence at Changli, Chihli, China, October 11, 1907. (Photographed by Frank N. Meyer.)

immense fuel yards, consisting entirely of the dried stalks of the kaoliang, are found at Tientsin and many other cities in the north of China.

Mr. Frank N. Meyer, Agricultural Explorer for the Office of Foreign Seed and Plant Introduction of this Bureau, has accumulated interesting information and photographs showing the uses of kaoliang in North China. In transmitting S. P. I. No. 17921, a brown-seeded sort collected at Peesan, Chihli, he states:²

(No. 22, a.) A variety with dark-brown seeds, universally used throughout North China as fodder for domestic animals. The stems of sorghum are used in building houses, the stalks being embedded in the mud walls; also for making fences, baskets, mats, tying and roofing material, and for fuel.

Figures 5 and 6 illustrate the use of stalks in making fences and baskets.

¹ Doolittle, Justus. *Social Life of the Chinese*, 1866, p. 43; revised edition by E. P. Hood, 1868, p. 25.

² Seeds and Plants Imported during the Period from December, 1905, to July, 1906. *Bulletin 106*, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1907, p. 60.

After his return from Manchuria Mr. Meyer prepared for the writer the following statement concerning the use to which the kaoliang is put by the Chinese:

Of the many crops the Chinese grow in North China, the sorghum is unmistakably the most important and the most useful. Without it life in a great part of North China and Manchuria would be almost impossible, for the variety of uses to which the kaoliang is put are legion, and it could not very well be replaced by any other single crop.

The light-colored varieties are ground into flour, out of which cakes are made, or they are simply boiled in water and served in the form of a gruel to the Chinese laborers,



FIG. 6.—Basket made of kaoliang stalks, containing giant red radishes, outside the city wall of Changli, Chihli, China, October 15, 1907. (Photographed by Frank N. Meyer.)

and it is amazing to see how much a Chinese can eat of it. I have seen my own interpreter eat three big bowlfuls for breakfast in the early morning and still feel comfortable. The dark-colored seeds are considered coarser and are used for distilling purposes and as fodder for horses and cattle. Nearly all of the fiery spirits that are used in North China (the so-called *samshu*) are distilled from these seeds, which are carted about the country in amazing quantities. As a feed for horses and mules one certainly can say that the kaoliang seeds, especially the dark-colored ones, in North China and Manchuria, take the same place that oats do with us.

The stalks of kaoliang are almost as valuable to the Chinese as the grain itself. In the semiarid north, where all of the wild, arboreal vegetation has either been exterminated, or at least has been reduced to such an extent as not to form an important item any longer, one finds that the stalks are the chief supply of fuel. They are used to cook the food, to heat the brick bedsteads in winter time, to boil the water for

tea; in fact, are used whenever heat is needed. Another important rôle they play is in the fine fencing material they furnish. In North China, in winter time, the icy wind blows with great violence all over the plains. To protect themselves, at the approach of the cold season the Chinese build fences around their houses, yards, pigpens, etc., and comfort would certainly be still more reduced in North China if these kaoliang-stem windbreaks were unobtainable.

These stalks are used also as supports for plants in the vegetable gardens. They serve as poles for beans, cucumbers, and yams. [See fig. 7.] They also lend themselves to basket and matting making, and in Shantung I even observed highly colored varieties that were grown for the express purpose of furnishing fancy basket and matting materials. In making the finer qualities of baskets the outer skin only is



FIG. 7.—Kaoliang stalks used as poles to support a yam, *Dioscorea* sp., Changtchou, Chihli, China, October 2, 1907. (Photographed by Frank N. Meyer.)

used, being split off by hand and woven into the various articles desired by skilled men and women. For large, coarse baskets, however, the whole stems are taken while they are still fresh, for when once dry they can not be manipulated very well.

Still another use the Chinese have for these stems is to chop them up, mix them with a few handfuls of boiled black soy beans, or kaoliang seeds, or bean cake, and serve them to their hard-working horses, mules, and donkeys—in the greater part of North China about the only food the draft animals ever get.

One would think by this time that the list of uses for the stems was pretty nearly exhausted, but there are still a few more; for instance, when an ordinary Chinese laborer builds himself a home he first erects a frame of poplar and willow poles; between these he places kaoliang stems. The whole frame is then smeared over with mud, in

which chopped-up straw or hairs has been mixed, and the house is then ready to move into. In the primitive greenhouses of the Chinese these sorghum stems serve as bars to hold the paper windows. They also constitute the frame of the roof, upon which the clay is smeared.

There are several minor uses yet for these stems, such as frames for kites, paper animals, playthings for children, etc., but I am afraid that the list would be too long to add here.

A last item about the kaoliang: Even the roots are not allowed to stay in the ground, but are carefully grubbed out by a stroke of a peculiar hoe or grub and a pull with one hand, are dried, stacked up in bundles, and sold and used all over the land for fuel. One certainly might ask, what would the farmer of North China do if he had no kaoliang to fall back upon.

In the "Report of an Investigation of the Scientific and Economic Relations of the Sorghum Sugar Industry," made by a special committee of the National Academy of Sciences, are given some notes on the uses of kaoliang, contributed by Dr. S. Wells Williams,¹ professor of oriental languages at Yale University. Like nearly all writers previous to the last few years, he confuses the sorgo grown locally on and near Tsungming Island, Chekiang, with the kaoliangs grown generally throughout northern China. The uses he mentions are for the kaoliang plant, except perhaps the reference to the practice of chewing the stems. His statements regarding its uses are as follows:

The Chinese are abundantly supplied with good and cheap sugar in all portions of their empire, coming from the sugar canes of the south; they have, consequently, no need of other sources than this plant. Their uses for sorghum are various—fodder for cattle from its leaves, fuel, wattles for fences, etc., from the stalks. In binding several of these together and cementing with clay they get a cheap substitute for posts, while the stalks in many ways take the place of timber.

Many varieties of the grain, black, red, and white, are known to the farmer. Its seeds, which are abundant, are used for making a sort of spirits, also occasionally for feeding to horses, mules, and camels.

The plant is almost wholly confined in its cultivation to the provinces north of the Yangtze River and forms in this region one of the principal crops. It is not employed as food for man save in times of famine and great stress. When ripe the grain is about the size of duck shot. * * *

The 20 or more varieties² which President Angell brought from China could probably be increased in number if the collection were made from a more extended area.

The uses of this plant for fuel tend to increase attention to the development of its stalk rather than the grain.

The plant often attains a height of 15 or 16 feet. The common practice of stripping off all the leaves within reach upon the growing stalk for feeding cattle increases very materially its woody fiber. Cutting the stems while in their prime of growth and chewing them green, as Southerners do the sugar cane, is not unusual in the North.

Kaoliang becomes less extensively grown as one goes southward in China, but the number of uses to which it is put does not diminish

¹ Williams, S. Wells. On the Sorghum (Kow-liang) of China. Report, National Academy of Sciences, November, 1882, pp. 57-58. 1883.

² Collier, Peter. Sorghum. American Agriculturist, vol. 45, 1886, p. 153.

in proportion. Chekiang is the most southern coastal province from which samples have been received. A brown-seeded kaoliang (S. P. I. No. 16792) was obtained with other seeds at Hangchow, in Chekiang, by Vice Consul Frederick D. Cloud in 1905. In sending them, after discussing the mixing of kaoliang seed with soy beans and other forage for horse feed, he says:¹

Perhaps the "kaoliang" is the most highly prized of all forage plants grown in China. No part of the plant goes to waste. Two or three weeks before the plant matures and the seed is ripe the farmer strips nearly all the blades from the plant, ties them in bundles, allows them to cure in the sun for a few days, and then stacks them away indoors. All through the winter these blades are keenly relished by horses and donkeys. Then the seeds are gathered, combed out, and marketed. Several varieties of alcohol and wines are made from these seeds, and the deadly native drink "sam-shu"—at least one variety of it—is made from "kaoliang" seed. The seed makes excellent food for stock of all kinds. The long stalks are thrown on the thrashing floor, rolled flat by heavy stone rollers, carefully cleaned of all particles of pith, and woven into a great variety of mats and matting, suitable for use on floors, for window shades, or for the roofs of native houses and sheds. These stalks are also extensively used for fuel by the farming class. It is a most valuable crop and may be found throughout all the northern provinces. Not grown much as far south as Hangchow.

As previously noted, Wilson² states that in southwestern China, in the provinces of Yunnan and Szechwan, 90 per cent of the seed is used for making wine, being only occasionally employed for food, more particularly in the mountain districts. Several years later, while employed as a collector for the Arnold Arboretum, Jamaica Plain, Mass., he obtained three lots of brown-seeded kaoliang (S. P. I. Nos. 21676-21678) at or near Ichang, in the province of Hupeh. In the notes transmitted with the seed he says:³

In this part of the Yangtze Valley the sole use of sorghum (kaoliang) is for making wine and spirits. I can find no record of its being used for food, even by the peasants.

As noted by Rein,⁴ Bellows,⁵ and Sawano,⁶ the chief use of kaoliang in Japan is for a windbreak or border about fields, while forms with longer panicles and shortened rachis are utilized for making brooms. Occasionally it is used for human food, concerning which Sawano says: "The seeds or grains are used generally for a kind of cake or pudding, which we call 'mochi.'"

The different uses tabulated below have been specified by the collectors of the samples of seeds listed by number and by the authors whose names are given. The full text of the notes made by the col-

¹ Seeds and Plants Imported during the Period from December, 1903, to December, 1905. Bulletin 97, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1907, pp. 237-238.

² Wilson, E. H., loc. cit.

³ Seeds and Plants Imported during the Period from July, 1906, to December 31, 1907. Bulletin 132, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1908, p. 175.

⁴ Rein, J. J., loc. cit.

⁵ Bellows, E. C., op. cit.

⁶ Sawano, J., op. cit.

lectors will be found in connection with the descriptions arranged numerically on later pages of this bulletin. It is probable that there are numerous other local uses for the plant which are not recorded in the tabulated list.

TABLE I.—*Classified uses of the kaoliang plant in eastern Asia.*

Material used and nature of use.	Designation of seed samples representing varieties so used.	Citation of other authorities for such use.
Grain:		
Feed.....	S. P. I. Nos. 6004, 16792, 17921, 17922, 21078, 29057-29058.	Meyer, Sammons, Williams.
Food.....	Agrost. No. 1586; S. P. I. Nos. 3863, 6406, 6411, 6604, 6710, 17920, 17922, 17923, 21077, 21078.	Doolittle, Meyer, Sammons.
Liquor.....	S. P. I. Nos. 3863, 4905, 6004, 16792, 21676-21678.	Doolittle, Meyer, Sammons, Williams, Wilson.
Heads:		
Brooms.....	Agrost. No. 1585; S. P. I. Nos. 18613, 20627, 22012.	Rein, Sammons.
Fuel.....		Sammons.
Leaves:		
Fodder.....	S. P. I. Nos. 3863, 16792, 17923, 29057-29058.	Meyer, Sammons, Williams.
Mats.....		Sammons.
Roots:		
Fuel.....	S. P. I. No. 17923.....	Meyer, Sammons.
Stalk:		
Baskets.....	S. P. I. No. 17921.....	Meyer (fig. 6).
Bridges.....		Sammons.
Building.....	S. P. I. No. 17921.....	Meyer, Sammons, Williams.
Fences and hedges.....	S. P. I. Nos. 3863, 17921.....	Doolittle, Meyer (fig. 5), Sammons, Williams.
Fodder.....		Meyer.
Fuel.....	S. P. I. Nos. 3863, 16792, 17921, 29057-29058.	Doolittle, Meyer, Sammons, Williams.
Kite frames.....		Meyer.
Lath.....		Doolittle, Meyer.
Matting.....	S. P. I. Nos. 16792, 17921, 22011 (red)...	Meyer, Sammons.
Playthings.....		Meyer.
Posts.....		Williams.
Sugar.....	Agrost. No. 1584.	
Thatching.....	S. P. I. Nos. 16792, 17921.....	Sammons.
Tying material.....	S. P. I. No. 17921.....	
Trellis.....		Meyer (fig. 7).
Window frames.....		Meyer.
Window shades.....	S. P. I. No. 16792.....	
Whole plant:		
Alkali-resistant crop.....	S. P. I. Nos. 18610-18612, 19187, 22012...	
Windbreak.....	Agrost. Nos. 1576, 1586.....	Meyer, Rein.

KAOLIANGS IN THE UNITED STATES.

INTRODUCTION OF VARIETIES.

It is possible that seeds of kaoliang varieties were sent to this country previous to 1860, but no record of such introduction has come to the attention of the writer. At various times from 1793 to 1861, kaoliangs had been noted by English diplomatic officers and others¹ as growing abundantly along the Pei from Taku to considerably above Tientsin in Chihli. There is no indication, however, of any attempts to introduce this crop into western lands.

¹ Bretschneider, Emil. History of European Botanical Discoveries in China, vol. 1, 1898, pp. 157-158, 226, 513.

Fortune, Robert. A Narrative of a Journey to the Capitals of Japan and China, 1863, pp. 316, 346.

HISTORY OF EARLY INTRODUCTIONS.

In 1865 Mr. Varnum D. Collins was sent to China to study the methods supposedly used by the Chinese in making sirup and sugar from sorgo.¹ He was also commissioned to get additional sorgo varieties for use in sugar-making experiments in the United States. In the paper cited he makes no reference to the sending of any seeds of kaoliangs to this country. From other sources, however, we know that four lots of seeds were received from him and that some of them



FIG. 8.—Plants of Brown kaoliang varieties, Arlington Experimental Farm, Va., September 22, 1933: *a*, Meyer Brown (Agrost. No. 1454, S. P. I. No. 6411), from Chosen (Korea); *b*, Baird Brush (Agrost. No. 1453, S. P. I. No. 6406), from Chosen (Korea); *c*, Hansen Brown (Agrost. No. 1448, S. P. I. No. 38C3), from China; *d*, Hansen Brown (Agrost. No. 1444), "Red" from California experiment station.

were kaoliangs.² These were probably sent after his paper was written. There is no record of what became of them and it is probable that when the stems were found lacking in saccharine juice they were discarded without even so much as having been described. They constitute the first recorded introduction of kaoliangs into the United States.

¹ Collins, Varnum D., loc. cit., p. 91; Clough, William J., *Sorgo Journal* (editorial), vol. 7, 1869, p. 91; Williams, S. Wells, Report, National Academy of Sciences, 1882, p. 57, 1883.

² Clough, loc. cit.

Dr. Peter Collier, formerly chemist of the Department of Agriculture, states ¹ that in 1881 he received, through President Angell, minister to China, six varieties of sorghum seed, the names of which were as follows:

Hwong-mao-nien-liang—Yellow-cap-glutinous-millet.
 San-sui-hung-liang—Separated-headstalks-red-millet.
 San-sui-pai-liang—Separated-headstalks-white-millet.
 Er-chiu-hung-liang—Second autumn-red-millet.
 Ma-wei-nien-liang—Horse-tail-glutinous-millet.
 Ta-min-hung-liang—Large-people's-red-millet.

The third and fourth varieties are depicted in plates 3 and 4 of Collier's work. Apparently they represent, respectively, a white-seeded sort with large, loose panicles, similar to S. P. I. No. 17920, and a brown-seeded variety with small and very compact panicles resembling S. P. I. No. 18518.

These six varieties, which came from Peking, were grown by Dr. Collier at Washington, D. C., in 1882, with many other varieties from other countries. That they were all true kaoliangs is evident from his comparison ² of them chemically with saccharine varieties from other sources. He states, further, that all except the first of these Chinese sorts belong to his fifth class; that is, they produce a single stalk from each seed, with no suckers from the roots but with branches at every joint of the parent stalk. The first variety produced sometimes two main stalks from a seed and sometimes a single stalk, and later produced suckers from the roots.

Several references ³ have also been found to 20 varieties of non-saccharine sorghum said to have been received from President Angell, who had obtained them in and about Peking. From an article by Dr. Collier ⁴ it appears that these 20 lots did not represent a later shipment, but that the 6 lots of seed previously discussed were found, on growing them, to represent 20 different forms.

A few years after the testing of the varieties obtained in China by President Angell, the Kansas Agricultural Experiment Station ⁵ grew and reported on three varieties in 1890. They were obtained through Consul B. F. Franklin at Hankow, which is in Hupeh Province and is also the source of S. P. I. Nos. 4905 and 6604.

These three varieties were described quite carefully, except that in the case of two of them the seeds are recorded as varying from

¹ Collier, Peter. *Sorghum: Its Culture and Manufacture*, 1884, pls. 3 and 4, p. 76.

² Collier, op. cit., pp. 101-107, 535-537.

³ Williams, S. Wells. *On the Sorghum (Kaoliang) of China*. Report, National Academy of Sciences, 1882, p. 58 [1883]; also quoted by Collier, op. cit., p. 52.

Denton, A. A., and Crampton, C. A. *Report on Sorghum Experiments at Sterling, Kans.* Bulletin 20, Bureau of Chemistry, U. S. Department of Agriculture, 1889, p. 112.

⁴ Collier, Peter. *Sorghum*. *American Agriculturist*, vol. 45, 1886, p. 153.

⁵ Georgeson, C. C. *Experiments with Forage Plants*. Bulletin 18, Kansas Agricultural Experiment Station, 1890, pp. 182-183.

white to red and, in one case, even to black, all in the same head. The apparent mixture of white and colored seeds in the same head is probably due to the well-known bleaching of the yellowish ovary just before the appearance of the pigment which gives the final color to the seed. There is no later record showing the final disposition of these three varieties and it is probable that they were discarded in favor of the kafirs, just then being introduced into cultivation.

RECENT INTRODUCTIONS AND THEIR SOURCES.

The official introduction of kaoliang varieties into the United States by the United States Department of Agriculture began with the receipt of S. P. I. No. 225 from North China in the year 1898. Between that time and the close of the year 1910 a total of 51 direct and 3 indirect introductions from eastern Asia had been made.

All varieties obtained or distributed directly by the Office of Foreign Seed and Plant Introduction of the Bureau of Plant Industry are given serial numbers called S. P. I. numbers. When such varieties are tested by the other offices of the Bureau interested in various crops, they are usually given a second number by the office testing them. The two offices which have tested kaoliangs are the former Division of Agrostology and the present Office of Grain Investigations. The writer has had charge of the study of these varieties in both offices.

In Table II these different kinds of numbers are arranged serially in parallel columns. The numbers in column 1 are those applied to a few of the earlier introductions by the Division of Agrostology. The numbers in column 2 are those given by the Office of Grain Investigations. Column 3 contains the original introduction numbers given by the Office of Foreign Seed and Plant Introduction so far as the varieties were obtained by that office. In order to maintain the serial arrangement it has been necessary to enter certain numbers twice. In such cases one entry is not in its proper numerical sequence and is therefore placed in parentheses. Where more than one S. P. I. number is found opposite a G. I. number it indicates that successive crops of improved seed grown in this country have been given new S. P. I. numbers to facilitate the records of distribution. Where an S. P. I. number has no parallel G. I. number it means that that introduction was not grown by the Office of Grain Investigations. In the single case where a G. I. number has no parallel S. P. I. number, viz, G. I. No. 28, it represents an independent accession, similar to those made by the former Division of Agrostology. This table shows also the source of the original seed and the variety of the kaoliang group to which it belongs.

TABLE II.—*List of numbers assigned to kaoliangs by the Division of Agrostology, by the Office of Grain Investigations, and by the Office of Foreign Seed and Plant Introduction, with varietal name and source of original seed.*

Agrost. No.	G. I. No.	S. P. I. No.	Varietal name.	Source.
		225	Hansen Brown	North China.
		939	Manchu Brown	Trans-Baikalia, Siberia.
1442			Brill Blackhull	California Experiment Station.
1443			Mukden White	Do.
1444			Hansen Brown	Do.
1448		3953	do.	China.
1450		4905	Tokyo Brown	Hupeh, China.
1453		6406	Baird Brush	Chosen (Korea).
1454		6411	Meyer Brown	Do.
1455	(326)	6604	Hansen Brown, Hankow Brown	Hupeh, China.
1457		6710	Brill Blackhull	Chihli, China.
1576			Tokyo Brown	Honshu, Japan.
1584			Paperhull	Do.
1585			Hoki Brown	Do.
1586			Tokyo Brown	Do.
	28		(Unnamed) Brown	China.
	(152)	16792	Valley Brown	Chekiang, China.
	120	17920	Brill Blackhull	Chihli, China.
	121	17921	Hansen Brown	Do.
	122	17922 (24990)	Peasan Brown	Do.
	123	17923 (24991)	Tientsin Brown	Do.
	152	(16792)	Valley Brown	Chekiang, China.
	171	18518 { 24992 24993 24994	Manchu Brown	Manchuria.
	190	18610	Mukden White	Chihli, China.
	191	18611	Manchu Brown	Do.
	192	18612	do.	Do.
		18613	Headlands Brush	Do.
		18614	Korean Brush	Do.
		18625	Meyer Brown	Do.
		18626	Chihli Brush	Do.
	193	19187	Kall Brown	Shengking, Manchuria.
	261	20612 (24995)	Manchu Brown	Manchuria.
	262	20620	do.	Usuri, Siberia.
	263	20621	Paperhull	Do.
	264	20627	Manchu Brown	Manchuria.
	265	20706	Korean Brush (?)	Usuri, Siberia.
	272	21077	Mukden White	Shengking, Manchuria.
	273	21078	Valley Brown	Do.
	276	21676	Ichang Brown	Hupeh, China.
	277	21677	Tokyo Brown	Do.
	278	21678	Shasi Brown	Do.
	293	22010	Shantung Dwarf	Shantung, China.
	(327)	22011	Redstem	Do.
		22012	(Unnamed) Brown	Do.
	309	22911	Valley Brown	Kiangsu, China.
	310	22912	Barchet Blackhull	Do.
	323	23230	Chusan Brown	Chekiang, China.
	324	23231	do.	Do.
	326	(6604, Kan. 595)	Hankow Brown	Kansas, U. S. A.
	327	(22011)	Redstem	Shantung, China.
	328	24478	Manchu Brown	Kirin, Manchuria.
	(122)	24990	Peasan Brown	Texas, U. S. A.
	(123)	24991	Tientsin Brown	Do.
	(171)	24992 { 24993 24994	Manchu Brown	Do.
	(261)	24995	do.	Do.
	412	27553	Korean Blackhull	Chosen.
	413	27554	Chooschun Brown	Do.
	414	27555	Moose Brown	Do.
	421	28027	Ware Brown	Kiangsu, China.
	423	28057	Valley Brown	Shengking, Manchuria.
	424	28058	Parker Brown	Do.

Table III shows the localities from which these varieties of kaoliang have been introduced. These localities are grouped by provinces, under the major political division of which they are a part. For each city and town the approximate latitude and longitude are given,

when the place could be found on recent maps. No attempt has been made to indicate the position more closely than by the approximate parallel and meridian.

As stated previously, it is not known whether the sample obtained in Siberia at 51° north latitude was grown there or was imported from some point in Manchuria having a more southern latitude.

TABLE III.—*Localities from which seeds of kaoliangs have been introduced, with the approximate latitude and longitude.*

Division.	Province.	Locality.	Position.	
			Latitude, N.	Longitude, E.
			Degrees.	Degrees.
Siberia.....	Trans-Baikalia.....	Nertchinsk.....	51	120
	Usuri.....	Vladivostok.....	43	132
Japan.....	Honshu.....	(Not designated).....	43-50	132-140
		Tokyo.....	36	140
		Yokohama.....	36	140
Chosen (Korea).....		Choonchun.....		
Manchuria.....	Kirin.....	Pingyang.....	39	126
		Harbin.....	46	127
	Shengking.....	Mukden.....	42	123
		Newchwang.....	41	122
China.....		Kungkitsewang.....	40	116
		Peking.....	40	116
	Chihli.....	Peesan.....		
		Shanhalkwan.....	40	120
		Tientsin.....	39	117
		Tsou.....	35	117
	Shantung.....	Chungdun.....	37	117
		Chingshan.....	37	118
	Kiangsu.....	Taungming Island.....	23	122
		Hankow.....	30	114
	Hupei.....	Ichang.....	31	112
		Wuchang.....	30	114
		Chusan Islands.....	30	122
	Chekiang.....	Hangchow.....	30	120

TESTING THE INTRODUCTIONS.

Some of the earlier introductions by the Office of Foreign Seed and Plant Introduction, as well as several lots obtained independently by the writer, were tested several years ago from the standpoint of forage production. Since it was immediately evident that the fodder was of little value they were mostly discarded after being grown but a single season. These early tests were made at the Arlington Experimental Farm of the Bureau of Plant Industry, at Arlington, Va., and many of them were duplicated at the State experiment stations at Knoxville, Tenn., Baton Rouge, La., and Hays, Kans. The writer wishes to express here his thanks to the directors of these stations and to the officers in charge of the experimental plats for their courteous and helpful cooperation in these tests. Thanks are also due to the Office of Forage-Crop Investigations, and especially to Mr. A. B. Conner, superintendent of the forage experiment station at Chilli-cothe, Tex., for assistance in cooperative varietal tests at that point.

Since the beginning of the year 1906 nearly all kaoliang introductions have been tested from the standpoint of grain production by the Office of Grain Investigations. As soon as an introduction has been received and given an accession (S. P. I.) number by the Office of Foreign Seed and Plant Introduction, the seed is transmitted to the writer for a test of its varietal and agronomic characters. After receiving a Grain Investigations (G. I.) number, a sample sufficient for a hundredth-acre nursery row is sent to the Amarillo experiment farm, which is the chief breeding station of the Office of Grain Investigations for grain sorghums. This farm is located only 2 miles from the town of Amarillo, in the Panhandle of Texas. The elevation is 3,600 feet, the average annual precipitation about 21 inches, the summer temperatures high, the humidity low, and evaporation rapid. These conditions are severe enough to quickly indicate undesirable sorts. The season is short enough to put varieties having early or medium maturity at a premium and yet long enough to permit a varietal study of later maturing forms.

If there is reason to believe, in advance of a test, that the introduction is especially early, the original seed is also tested the first season at one or two points in the North, such as the Bellefourche and Highmore experiment farms in South Dakota, but otherwise the preliminary test is confined to the Amarillo form.

The nursery row, grown from the original seed, is the basis of selection for future tests. If the crop proves early, with a satisfactory habit of growth and a desirable type of head, a considerable number of heads are selected for growing in head rows the following season at other points. If, as more commonly happens, the variety proves late, or of too tall a growth, or with an undesirable type of head, or a mixture of two or more forms, a limited number of heads are selected to be grown in head rows again the following season at the Amarillo experiment farm. Since the kaoliangs are likely to have a limited field of usefulness in this country, all selections are made looking toward the increase of the characters necessary to adapt the crop to the desired conditions.

These characters briefly are earliness, dwarf to medium stature, and compact to semicompact heads, well exerted and well filled. Such selection often quickly alters the nature of the variety so much along these lines that a description of the average plant from the original seed will scarcely fit the improved crop of two or three seasons later.

Table IV shows the varieties that have been under experiment during the period from 1906 to 1911, inclusive, in which the writer has been engaged in the study of sorghums from the standpoint of grain production. It will be seen that 35 introductions have been

studied during the period. Of this number 10 have been discarded as undesirable, about 15 are yet on probation, and about 10 are considered as fixed types of agronomic value. Five of this last group have already been distributed to cooperating farmers, one of the oldest selections (No. 171) in considerable quantity.

TABLE IV.—*Years in which recent kaoliang introductions have been tested at the experiment farm at Amarillo, Tex.*

G. I. No.	S. P. I. No.	Years grown.						G. I. No.	S. P. I. No.	Years grown.					
120	17920	1906	1907	1908	1909	1910	1911	277	21677						1911
121	17921	1906	1907					278	21678						1911
122	17922	1906	1907	1908	1909	1910	1911	293	22010			1908	1909	1910	1911
123	17923	1906	1907	1908	1909	1910	1911	309	22911			1908	1909	1910	1911
152	16792	1906						310	22912			1908	1909	1910	1911
171	18518	1906	1907	1908	1909	1910	1911	323	23230				1909		
190	18610		1907	1908	1909	1910	1911	324	23231				1909	1910	1911
191	18611		1907	1908				326	6604				1909	1910	1911
192	18612		1907	1908				327	22011				1909	1910	1911
193	19187		1907	1908	1909	1910	1911	328	24478			1909	1910	1911	
261	20612		1907	1908	1909	1910	1911	350	27764				1910	1911	
262	20620		1907					412	27553					1910	1911
263	20621		1907	1908				413	27554					1910	1911
264	20627		1907					414	27555					1910	1911
265	20706		1907	1908				421	28027					1910	1911
272	21077		1907	1908	1909	1910	1911	423	28057					1910	1911
273	21078		1907	1908				424	28058					1910	1911
276	21676						1911								

¹ Did not germinate.

DESCRIPTIVE LIST OF INTRODUCTIONS.

The following list includes all official introductions of kaoliangs by the United States Department of Agriculture, with a single exception, so far as they are known to the writer. The exception noted is G. I. No. 28, the seed of which did not germinate. The list contains also those home-grown selections, from original introductions, which have been given new numbers. The six lots represented by Nos. 24990 to 24995 are examples of such renumberings of improved strains.

The first seven numbers described are those received independently and accessioned by the former Division of Agrostology. Then follow in numerical sequence the numerous introductions and accessions by the Office of Foreign Seed and Plant Introduction, 52 in all, making a total of 59 separate lots described. The 27 varieties herein described include 58 of the 59 lots. A single introduction, S. P. I. No. 22012, remains unidentified for lack of sufficient data.

The varieties proposed herein must be understood in the broad sense in most cases. They are group varieties rather than races or strains. From most of them it is possible to isolate strains sufficiently distinct from each other to be worthy of separate names when grown several years and fully described.

It is probable that most of the major group varieties have now been obtained and studied. Many minor forms doubtless exist in China and Chosen (Korea), which have not yet been introduced into this country. They will probably all be found to come within the limits of the group as here outlined. Most of them are likely also to fall into the group varieties as hereafter described under the classification of the kaoliangs.

In characterizing the different introductions little mention has been made of the leaves or of the awns on the lemmas or flowering glumes. The leaves are small compared with those of kafirs or of most sorghos and are more comparable in size to those of Amber sorgho and the milos. In general, the leaves are proportionate to the size and height of the culm and present no distinctive features. The same is true of the awns, which are universally present.

The terms used in describing the colors of the seeds and glumes are those by Ridgway.¹

Very few of the many kaoliang introductions have distinctive native names, so far as is indicated by the notes accompanying the seeds. In the few cases where native names are known they are usually too long or too difficult in spelling for use as varietal names. It has therefore been necessary to choose a name for each of the 27 varieties described. The endeavor of the writer has been to apply short and simple names, as was done previously in the case of soy bean varieties,² and it is hoped that these names may commend themselves to agronomists and crop breeders. The second word of the double names, as White, Blackhull, Brown, etc., will doubtless be dropped in the case of varieties which finally become well known.

AGROSTOLOGY NUMBERS OF INTRODUCTIONS.

1442. *Brill Blackhull*. Received as "Blackhull White kaoliang," by Mr. Ball, from the California experiment station (No. 142-1900) in 1902; grown at the Arlington Experimental Farm in 1903. Plants 7 to 10 feet high, slender, heading in 95 days when sown May 20, and bearing large, lax, oval-oblong panicles 10 to 14 inches in length; spikelets 5.5 mm. long; seeds white, narrowly oval, 4.5 to 5 mm. long by 3 to 3.5 mm. wide, three-fourths inclosed by shining black glumes. Some plants bore panicles somewhat umbelliform, with longer drooping branches. There was also an admixture of a brown kaoliang with more compact and oblong panicles.

1443. *Mukden White*. Received as "White glutinous kaoliang" from the same source as No. 1442. Grown at the Arlington farm in 1903, only a few seeds germinating; plants 8 to 9 feet tall, heading in 94 days from seed sown on May 20; panicles lax, ovate pyramidal, 10 to 12 inches long; spikelets 4 to 6 mm. long, broadly oval; seeds 4 to 5 mm. by 3 to 3.5 mm. wide, oval or obovate oval, white, about one-third exerted; glumes 3 to 4 mm. long, firm, buff to orange buff and orange vermillion.

¹ Ridgway, Robert. A Nomenclature of Colors for Naturalists, 1886, 129 pp., 17 pls.

² Ball, Carleton R. Soy Bean Varieties. Bulletin 98, Bureau of Plant Industry, U.S. Dept. of Agriculture, 1907, 30 pp., 5 pls. (Of 23 varieties described in this paper, names were made outright for 18 and simplified for 3 of the remaining 5.—C. R. B.)

1444. *Hansen Brown* (fig. 8, a). Received as "Red kaoliang" from the same source as No. 1442. Grown at Arlington farm in 1903, producing heads in 90 days on plants 10 feet high, bearing large, lax, oval panicles 12 to 14 inches long; spikelets 4.5 to 5.5 mm. long; seeds 4 to 5 mm. long by 3 to 4 mm. wide, obovate or oval, burnt sienna to cinnamon and buff; glumes black, shining, 4 to 4.5 mm. long.

1576. *Tokyo Brown*. Received from Hon. E. C. Bellows, consul general, Yokohama, Japan, on March 6, 1903, with the following note:

I have the honor to transmit a package of Japanese sorghum seed, of the kind known as *morokoshi-kibi*. Messrs. L. Boehmer & Co., horticulturists, of Yokohama, who have furnished this seed without charge, inform me that this sorghum "is of very little importance in Japan, being generally planted along the borders of fields only, in order to protect the field crops against winds, etc. In some parts of the country where rice and other cereals do not grow, sorghum is, to a certain extent, cultivated as a field crop. It is sown in April in seed beds and later transplanted at intervals of 8 or 10 inches." (Bellows.)

Grown at Arlington farm in 1903; plants very slender, 5 to 7 feet in height, producing heads in 95 days; panicles ovate pyramidal or somewhat oval, heavy, 6 to 11 inches long; spikelets 3.5 to 4.5 mm. long; seeds 3 to 4.2 mm. by 2.8 to 3.8 mm. wide, from broadly obovate to nearly lenticular; chestnut to burnt sienna; glumes clay to vinaceous cinnamon and maroon, somewhat gibbous at the base, transversely shouldered above the middle, the apex strongly depressed, closely appressed to the seed.

1584. *Paperhull*. Received from Dr. J. Sawano, imperial experiment station, Tokyo, Japan, April 23, 1903, accompanied by the following memorandum:

Andropogon sorghum Brot. var. *saccharatus* Koern. Japanese name, *sato-morokoshi* or *rozoku*. This plant was introduced into this country from China about 28 years ago. For many years we tried to prepare sugar from it in many localities, but with poor success, on account of climatic and other circumstances. At the present time it was difficult to obtain even the small quantity sent. (Sawano.)

Grown at Arlington farm in 1903; plants 5 to 6 feet tall with very slender stalks, producing heads in 92 days when sown May 27; panicles ovate conical, slender, 6 to 10 inches long, often one-sided and hence right-angled triangular by the bending of the peduncle; spikelets 4.5 to 5.5 mm. long; glumes black or occasionally maroon, thin, papery, equaling the seeds; seeds 3 to 4.5 mm. by 2.5 to 3.5 mm. wide, oval, russet.

1585. *Hoki Brown*. Source, the same as No. 1584.

Andropogon sorghum Brot. var. *obovatus* Hack. Japanese name, *hoki-morokoshi*. Its cultivation is quite similar to that of *morokoshi* (see No. 1586); cultivated principally for the ears or top part of the plant, from which, after the seeds are thrashed out, we make brooms, so that the name *hoki*, meaning broom, is given to the plant. It is harvested when fairly, but not fully, ripe because when overripe it is too weak or brittle to be used. (Sawano.)

Grown at Arlington farm in 1903; sown May 27 it produced heads in 90 days. The description will be found under this variety in the chapter on classification.

1586. *Tokyo Brown*. Source same as for 1584.

Andropogon sorghum Brot. var. *vulgare* Hack. Japanese name, *to-kibi*. It is generally planted along the boundary of a farm plat as a wind shelter for another principal summer crop. Its cultivation is very easy, and, indeed, the farmer does not pay much attention to it. In May or June the seeds are sown in one or two rows. It is harvested about October or November, when the heads turn yellowish in color. (Sawano.)

Grown at Arlington farm in 1903; plants 6 feet high, producing heads in 90 days when sown May 27 and bearing very heavy, oval panicles, 8 to 11 inches long and 4 to 5 inches wide, frequently one-sided from the bending of the stems; branches spreading or ascending; spikelets broadly obovate, 3 to 4 mm. in length; glumes brick red to maroon, otherwise as in No. 1576; seeds 3 to 4 mm. long by 2.5 to 3.7 mm. wide, broadly obovate to nearly lenticular, chestnut to blackish at the apices.

FOREIGN SEED AND PLANT INTRODUCTION NUMBERS.

225. *Hansen Brown*. Received from North China from Prof. N. E. Hansen in March, 1898. "Ga-oo-lan, used for human food." Not grown by the writer and no record of its habit on file; spikelets 4 to 5.2 mm. in length; glumes black, shining; seeds 3.5 to 5 mm. long by 2.5 to 3.5 mm. wide, obovate oval, exserted about one-fourth their length, walnut brown to burnt umber.

939. *Manchu Brown*. Received from Nertchinsk, Siberia, through Prof. N. E. Hansen, May 24, 1898; collected by Mr. Roborovsky. Not grown by the writer, but grown by Mr. J. E. Payne at Cheyenne Wells, Colo., in 1900. He notes that when planted April 27 it matured earlier than Early Amber sorgho; spikelets 4.5 to 5 mm. long; glumes black, shining, 3 mm. long; seeds 4 to 4.5 mm. by 3 to 4 mm., obovate oval to sublenticular, chocolate or walnut brown to buff, exserted nearly one-half.

3863 (Agrost. No. 1448). *Hansen Brown* (fig. 8, b). Received from China through Dr. H. W. Wiley, Chief of the Division of Chemistry, September, 1899.

"*Kao liang*."—From 10 to 15 feet in height; growth similar to corn; stalk used for fuel and hedges; leaves stripped for fodder; grain extensively used for food and in the manufacture of alcohol.

Grown at Arlington farm in 1903; plants 10 feet in height, very late, heading in 100 days, ripening in 140 days; panicles large, lax, oblong oval or sometimes closely ovate, 12 to 14 inches long; spikelets 4.5 to 5.5 or 6 mm. long; glumes black, shining, 4 to 5 mm. long; seeds 3.5 to 5 mm. by 2.5 to 3 mm., obovate oval, bay to walnut brown.

4905 (Agrost. No. 1450). *Tokyo Brown*. Received from Wuchang, Hupeh, China. Presented by Messrs. G. D. Brill and J. W. Gilmore.

Loh goa liang (No. 38). This is a nonsaccharine sorghum. There are two or three kinds, but the main use of all is for making a kind of whisky. (Gilmore.)

Grown at Arlington, Va., Knoxville, Tenn., and Baton Rouge, La., in 1903. No germination obtained at Arlington and very poor germination elsewhere. Plants 1.5 to 1.8 meters (5 to 6 feet) in height, stooling freely; panicles oval, lax, large, 2.5 to 3.5 dm. (10 to 14 inches) long, the branches 1.5 dm. (6 inches) long and drooping, the apex of the panicle often nodding; spikelets 2.3 to 4 mm. long, almost spherical; glumes coriaceous, gibbous at the base, transversely ridged above the center, the apex strongly depressed and closely appressed to the seed, mostly cream buff shaded to heliotrope, to burnt sienna and claret; seeds 2.5 to 3.5 mm. by 2.5 to 3 mm., very broadly obovate or mostly sublenticular, clay to dark clay or darker, nearly included.

6406 (Agrost. No. 1453). *Baird Brush* (fig. 8, c). Received from Pyeng Yang (Ping-yang), Chosen (Korea), May 3, 1901. Presented by Rev. W. M. Baird.

A kind of grain similar in appearance to broom corn or sugar cane. The seeds are eaten. The canes are very straight and quite useful. Planted in May. (Baird.)

Grown at Arlington, Va., in 1903. Plants 1.8 to 2.7 meters (6 to 9 feet) in height; panicles slender, light colored, umbelliform, 3 to 5 dm. (12 to 20 inches) long, the apex nodding from the weight of seed; spikelets 4.5 to 6 mm. long; glumes shining, clay to tawny; seeds 4 to 5 mm. by 3 to 3.5 mm., oval, flattened, one-fourth exserted, clay to russet. A tall and medium-late variety, ripening in 120 days after planting.

6411 (Agrost. No. 1454). *Meyer Brown* (fig. 8, d). Source of seed same as for No. 6406.

Kind of grain similar in appearance to broom corn and sugar cane. The grain is eaten by Koreans. The canes are straight and valuable. (Baird.)

Grown at Arlington, Va., in 1903. Plants 1.8 to 2.4 meters (6 to 8 feet) in height, rather slender; panicles large, heavy, compact or semicompact, 1.5 to 2.5 dm. (6 to 10

inches), mostly one-sided from the leaning of the stalks and peduncle, dark red from the large and well-exserted seeds; spikelets 4 to 5.5 mm.; glumes black, shining; seeds 3.5 to 5 mm. long by 2 to 4 mm. wide, oval or obovate oval, a few sublenticular, exserted one-fourth to one-third, russet to walnut and chocolate. A variety of medium height and medium early in maturity, ripening in 120 days.

6604 (Agrost. No. 1455; also G. I. No. 326 selected from Kansas experiment station No. 595, which was grown from original seed of S. P. I. No. 6604). Hansen Brown in part; Hankow Brown in part (Pl. II, I). Received from Hankow, China, under the name "Barbados millet," May 17, 1901. Presented by Mr. G. D. Brill.

Grown at Arlington, Va., Knoxville, Tenn., Baton Rouge, La., and Hays, Kans., in 1903. It proved to be a decided mixture, containing the tall, late variety Hansen Brown, 2.4 to 3 meters (8 to 10 feet) in height, stout, with large leaves and large ovate or conical panicles, some lax, some more dense. It contained also one early strain of medium height which, without doubt, is the one later designated as G. I. No. 326. In 1903 the writer was concerned only with forage-producing varieties and this one was no longer grown. In 1908, however, when engaged in the study of grain-producing sorghums, he obtained from the Kansas experiment station a sample of their No. 595, which was designated as G. I. No. 326. This was ascertained to have been produced from S. P. I. No. 6604 and quite certainly represents the early strain noted in 1903. This Kansas strain was grown at Amarillo, Tex., in 1909 and may be described as follows: Plants 1.5 to 1.8 meters (5 to 6 feet) in height; panicles oval oblong, 2 to 2.7 dm. (8 to 11 inches) in length, some compact with continued rachis and also branches 6 to 10 cm. long, often naked for more than half their length; spikelets 3 to 4.5 mm. long; glumes mostly black and shining; seeds 3 to 4 mm. long by 2 to 5.3 mm. wide, obovate to broadly obovate or sublenticular, cream to burnt sienna, scarcely exserted. An early variety, maturing in 95 to 100 days from planting.

6710 (Agrost. No. 1457). *Brill Blackhull*. Received from Peking, China, June 12, 1901, through Mr. G. D. Brill (No. 156).

"This is much grown for human food around Peking and is considered much superior to the other varieties." (*Brill*.)

Grown at Arlington, Va., and Baton Rouge, La., in 1903. No germination was obtained at the former place and only three or four seeds grew at the latter. Plants 2.4 to 2.7 meters (8 to 9 feet) in height, suckering abundantly by reason of the thin stand; heads oval, lax, large, 2.5 to 3.5 dm. (10 to 14 inches) long, 2 to 2.5 dm. (8 to 10 inches) in width. Spikelets 4.5 to 6 mm. long; glumes black, shining; seeds narrowly oval to oval, 4 to 5.5 mm. long by 3 to 4 mm. wide, white. A tall and late variety, maturing in 120 to 140 days.

16792 (G. I. No. 152). *Valley Brown*. Received from Hangchow, China, December 15, 1905, through Mr. Frederick D. Cloud, American vice consul.

This bean (Black soy, No. 16796) mixed with "kaoliang" (sorghum) seed, chopped grass, or straw, with a little bran, makes the very best horse feed. Perhaps the "kaoliang" is the most highly prized of all forage plants grown in China. No part of the plant goes to waste. Two or three weeks before the plant matures and the seed is ripe the farmer strips nearly all the blades from the plant, ties them in bundles, allows them to cure in the sun for a few days, and then stacks them away indoors. All through the winter these blades are keenly relished by horses and donkeys. Then the seeds are gathered, combed out, and marketed. Several varieties of alcohol and wines are made from these seeds, and the deadly native drink "sam-shu"—at least one variety of it—is made from "kaoliang" seed. The seed makes excellent food for stock of all kinds. The long stalks are thrown on the thrashing floor, rolled flat by heavy stone rollers, carefully cleaned of all particles of pith, and woven into a great variety of mats and matting, suitable for use on floors, for window shades, or for the roofs of native houses and sheds. These stalks are also extensively used for fuel by the farming class. It is a most valuable crop and may be found throughout all the northern provinces. Not grown much as far south as Hangchow. (*Cloud*.)

Grown at Chillicothe and San Antonio, Tex., in 1906. Plants 2.1 to 3 meters (7 to 10 feet) in height, 1.5 to 2 cm. in diameter at the butt, producing 1 to 3 suckers and bearing 9 to 13 leaves, 5 to 7 cm. (2 to 3 inches) wide and 6 to 7.5 dm. (2 to 2.5 feet) long; panicles broadly oval or occasionally ovate, large, 2 to 3.5 dm. (8 to 14 inches) long, 1 to 2 dm. (4 to 8 inches) wide; spikelets obovate, 4 to 5.5 mm. long; glumes 3.5 to 4.5 mm. long, buff to tawny or claret brown; seeds 3.5 to 5 mm. long by 2.5 to 4 mm. wide, obovate oval, chestnut to russet and buff. The original introduction contained a mixture of varieties and some hybrids. The principal variety, to which the name is applied, is of medium height and medium-early maturity, ripening in 100 to 105 days.

17920 (G. I. No. 120). *Brill Blackhull* (Pl. II, A). Received from Peesan, China, February 23, 1906, through Mr. Frank N. Meyer, Agricultural Explorer, Bureau of Plant Industry.

This variety has white seeds and is used for making bread; as such it is more highly esteemed than the brown-colored varieties, which are generally only used as fodder for the domestic animals. (*Meyer.*)

Grown in varietal test at Amarillo, Chillicothe, and San Antonio, Tex., in 1906. Plants 2.1 to 3.6 meters (7 to 12 feet) in height, partly proportionate to locality, producing 1 to 3 suckers and bearing 10 to 15 leaves each 6 to 7.5 cm. (2.5 to 3 inches) wide and 6 to 7.5 dm. (2 to 2.5 feet) in length; panicles broadly oval, lax, heavy (weighing 3 ounces each), 2.2 to 3.5 dm. (9 to 14 inches) long and 1 to 1.5 dm. (4 to 6 inches) wide, large, much-branched, the lower branches 1.2 to 2.5 dm. (5 to 10 inches) long, flexuous at the base, equaling the rachis, or one-half to seven-tenths as long as the panicle; spikelets obovate oval, 6 to 7 mm. long; glumes black, shining, 3 to 4.5 mm. long; seeds oval or narrowly oval, white, 4 to 6 mm. long by 3 to 3.5 mm. wide, one-third exserted; anthers pale yellow and stigmas white at San Antonio. A tall, late-maturing variety, ripening seed in 120 to 135 days from planting.

17921 (G. I. No. 121). *Hansen Brown* (fig. 9, left; Pl. II, E). Source the same as for No. 17920.

(No. 22, a.) A variety with dark-brown seeds, universally used throughout North China as fodder for domestic animals. The stems of sorghum are used in building houses, the stalks being embedded in the mud walls; also for making fences, baskets, mats, tying and roofing material, and for fuel. (*Meyer.*)

Grown in varietal test at Amarillo, Chillicothe, and San Antonio, Tex., in 1906. Plants 2.1 to 3 meters (7 to 10 feet) in height, 1.5 to 2 mm. (0.5 to 0.7 inch) in butt diameter; suckers, 1 to 3; leaves, 10 to 13, 5 to 8 cm. (2 to 3 inches) wide, 6 to 7.5 dm. (2 to 2.5 feet) in length; panicles broadly oval, semicompact to lax, 2 to 3 dm. (8 to 12 inches) long and 1 to 2 dm. (4 to 8 inches) wide; spikelets 5.5 to 6 mm. long; glumes black, shining, 4 mm. long; seeds 4.5 to 5.5 mm. long by 3.5 to 4.5 mm. wide, bay to cinnamon, one-half exserted. A tall and late variety, maturing in 125 to 140 days.

17922 (G. I. No. 122). *Peesan Brown* (Pl. II, N). Source the same as for No. 17920.

(No. 23, a.) A variety with light-brown seeds, not very much grown. It is used where found as a fodder plant and also for making a brown-colored kind of bread. (*Meyer.*)

Grown in varietal test at Amarillo, Chillicothe, and San Antonio, Tex., in 1906, and at different points continuously thereafter. Plants 2 to 2.4 meters (6.5 to 8 feet) in height; suckers, 1 to 3; leaves, 9 to 11, 5 to 7 cm. (2 to 2.6 inches) wide, 4.5 to 6 dm. (1.5 to 2 feet) in length; panicles erect, well exserted, ovate conical or frequently one-sided by the bending of the peduncle, 1.5 to 2.8 dm. (6 to 11 inches)

long, 1 to 1.5 dm. (4 to 6 inches) wide; spikelets oval, 4 to 5.5 mm. long; glumes 3.5 to 4.5 mm. long, clay to madder brown; seeds 3.5 to 5 mm. long by 3 to 4 mm. wide, mostly oval or some broadly obovate, russet to bay in the original sample, becoming cream buff to raw sienna and hazel in later years. A variety of medium-late maturity, ripening in 115 to 125 days. The strain under selection, G. I. No. 122, is about 5.5 feet in height and matures in 110 to 115 days.

17923 (G. I. No. 123); 24991. *Tientsin Brown* (fig. 9, right; Pl. II, F). Received from Tientsin, Chihli, China, through Mr. F. N. Meyer, February 23, 1906.



FIG. 9.—Plants of two brown kaoliang varieties, Hansen Brown (G. I. No. 121, S. P. I. No. 17921), and Tienstin Brown (G. I. No. 123, S. P. I. No. 17923), grown from original seed at Chillicothe, Tex., September 6, 1906. (Photographed by C. R. Ball.)

Kaulien sorghum of Manchuria, which forms the staple produce of that country and which has been made famous in the last year. It grows 8 to 10 feet high; the stalks and grain were indispensable for all concerned. (*Yokohama Nursery Co.*)

Grown in varietal test at Amarillo, Chillicothe, and San Antonio, Tex., in 1906, at various points in 1907, and in our regular field experiments each year thereafter. Plants low, 1.4 to 1.8 meters (4.5 to 6 feet) in height, .6 to 1 cm. (.25 to .40 of an inch) in butt diameter; suckers 1 to 3; leaves 7 to 9, small, 4 to 6 cm. (1.5 to 2.5 inches)

(No. 151. a.) A superior variety of sorghum which grows from 15 to 20 feet in height. The grain is ground, and from the flour a good kind of bread is made; is used also for the same purpose as the one described under No. 22, a (S. P. I. No. 17921). In addition to this the leaves are pulled off before they have turned brown, when they make an excellent cattle food, either fresh or dry. The roots are also dug and used as fuel. (*Meyer.*)

Grown in varietal test at Amarillo, Chillicothe, and San Antonio, Tex., in 1906, and at various points in 1907. A variety of medium height and maturity, ripening in 105 to 120 days. The large heads are not well filled at the base. It differs from Hansen Brown chiefly in being earlier. A description will be found under this variety in the classification.

18518 (G. I. No. 171); also 24992, 24993, and 24994. *Manchu Brown* (fig. 10; Pl. II, H). Received from Manchuria through the Yokohama Nursery Co., Yokohama, Japan, May 9, 1906.

wide, 3 to 4.5 dm. (1 to 1.5 feet) long; panicle well exserted, oval, 2 to 2.5 dm. (8 to 10 inches) long, the lower branches 5 to 10 cm. (2 to 4 inches) in length; rachis continuous; spikelets 4.5 to 6 mm. long; glumes black, shining; seeds obovate oval to oval, 4 to 5.5 mm. long by 3 to 4 mm. wide, walnut brown to burnt sienna or madder brown where exposed, and white to buff and russet where included in the glumes, one-third exserted; anthers and stigmas yellow. A low, early, and valuable variety, ripening in 90 to 100 days. Widely distributed to cooperating farmers at higher elevations in the central Plains area.

18610 (G. I. No. 190). *Mukden White* (fig. 11; Pl. II, *D*). Received from Shan-hai-kwan, Chihli, China, at the Plant Introduction Garden, Chico, Cal., from Mr. F. N. Meyer, May 18, 1906.

(No. 153, *a.*) A white-grained variety of sorghum grown on rather alkaline land. (*Meyer.*)

Grown at Amarillo and Chillicothe, Tex., Modesto, Cal., and North Platte, Nebr., in 1907. Plants 1.5 to 2.4 meters (5 to 8 feet) in height, rather stout, 1.2 to 2.5 cm.



FIG. 10.—Field of Manchu Brown kaoliang (G. I. No. 171, S. P. I. No. 18518), 5 feet tall, Amarillo, Tex., August 20, 1908. (Photographed by C. R. Ball.)

(0.5 to 1 inch) in butt diameter, mostly without suckers; leaves 8 to 11; panicles oval or ovate, rather heavy, 2 to 2.7 dm. (8 to 11 inches) in length, basal branches 1 to 1.5 (4 to 6 inches) long; spikelets broadly oval, 5 to 6 mm. long; glumes 3 to 4 mm. long, buff, shading strongly to orange buff and orange vermillion; seeds obovate oval, 4 to 5 mm. long by 3 to 3.5 mm. wide, white, one-third exserted. A medium-tall variety, medium early to medium late in maturity, ripening in 105 to 115 days. One early head was noted as having deciduous spikelets, an unusual character which belongs to the wild species *Andropogon halepensis* Brot.

18611 (G. I. No. 191). *Manchu Brown*. Source same as for 18610.

(154, a.) A light-brown colored variety of sorghum grown on rather alkaline land. (Meyer.)

Grown in varietal test at Amarillo and Chillicothe, Tex., Modesto, Cal., and North Platte, Nebr., in 1907. Plants 1.5 to 2.1 meters (5 to 7 feet) in height, slender to stout; panicle small, oval, rather compact, 1.5 to 2.2 dm. (6 to 9 inches) in length, the lower branches 5 to 10 cm. (2 to 4 inches) long, the rachis five-sixths as long as the panicle; spikelets 4 to 5.5 mm. long; glumes black, shining; seeds obovate to broadly

obovate oval, 3.5 to 5 mm. long by 3 to 4 mm. wide, burnt sienna to cinnamon rufous to buff. A low to medium variety with small panicles, ripening in 100 to 105 days.

18612 (G. I. No. 192). *Manchu Brown*. Source the same as for No. 18610.

(155, a.) A dark-brown colored variety of sorghum grown on rather alkaline land. (Meyer.)

Grown at Amarillo and Chillicothe, Tex., Modesto, Cal., and North Platte, Nebr., in 1907. Plants slender, 1.5 to 2.1 meters (5 to 7 feet) in height; panicles medium size, light weight, lax, 2 to 2.7 dm. (8 to 11 inches) long; spikelets oval, 5 to 6 mm. long; glumes black, shining; seeds narrowly oval to oval or obovate, 4 to 6 mm. long, 2.5 to 4 mm. wide, russet to burnt umber and bay, one-third exserted. A low to medium variety, of medium early maturity, ripening in 100 to 105 days.

18613. *Headlands Brush*. Received from Peking, China, at the Plant Introduction Garden, Chico, Cal., through Mr. F. N. Meyer, May 18, 1906.



FIG. 11.—Plants of Mukden White kaoliang (G. I. No. 190, S. P. I. No. 18610), Amarillo, Tex., October 5, 1908. (Photographed by C. R. Ball.)

(No. 172, a.) White seeded. Given to me by Mr. J. T. Headlands, of the Methodist Mission, Peking. This is the drooping variety used to make brooms from. (Meyer.)

Grown at Chico, Cal., in 1906, but no record of its habit available. Planted at Chillicothe, Tex., in 1907, but the seed did not germinate. A description of the original panicle will be found under this variety in the classification.

18614. *Baird Brush*. Source the same as for 18613. "(No. 172, a.) Brown seeded."

Grown at Chico, Cal., in 1906, but no record is available. Grown at Chillicothe, Tex., in 1907. Plants slender, 2.4 meters (8 feet) in height; panicles subumbelliform, 3 to 3.7 dm. (12 to 15 inches) in length, lower branches 1.2 to 2 dm. (5 to 8 inches) long, and the rachis one-half to three-fourths as long as the panicle; spikelets 4.5 to 6 mm. long; glumes 4 to 5 mm. long, buff-yellow to burnt sienna; seeds obovate, obovate oval, or oval, 4 to 5.5 mm. long by 3 to 3.5 mm. wide, buff yellow and burnt sienna to bay, one-fifth to one-fourth exerted. A variety of medium height and of medium late maturity.

18625. *Meyer Brown*. Received from Kungkitschang, Chihli, China, at the Plant Introduction Garden, Chico, Cal., through Mr. F. N. Meyer, May 18, 1906. "(No. 171, a.) Red seeded."

Grown at Chico, Cal., in 1906, but no record available. Grown at Chillicothe, Tex., in 1907. Plants 2.4 meters (8 feet) in height; panicles sparse and rather slender, 2.5 to 3 dm. (10 to 12 inches) in length, the lower branches 5 to 12 cm. (2 to 5 inches) long, and the rachis two-thirds as long as, to equaling, the panicle; spikelets oval, 4.5 to 6 mm. long; glumes seal brown or black; seeds oval or obovate, 4 to 5.5 mm. long by 2.8 to 3.8 mm. wide, russet to bay. A variety of medium height and medium-late maturity, ripening in 115 days.

18626. *Chihli Brush*. Source the same as for 18625. "(No. 171, a.) White seeded."

Grown at Chico, Cal., in 1906, but no record available. Grown at Chillicothe, Tex., in 1907. A description will be found under this variety in the classification.

19187 (G. I. No. 193). *Kali Brown* (Pl. II, G). Received from Newchwang, Manchuria, through Mr. F. N. Meyer, August 28, 1906.

(No. 259, a) Chinese name, *kauliang*. A brown-colored variety of sorghum, said to be grown on the rather alkaline lands around Newchwang. (Meyer.)

Grown in varietal test at Amarillo and Chillicothe, Tex., Hays, Kans., North Platte, Nebr., Highmore, S. Dak., and Modesto, Cal., in 1907. A description will be found under this variety in the classification. A low to medium variety, early to medium early in maturity, ripening in 100 to 110 days. Differs from Manchu Brown chiefly in greater height and later maturity. Name suggested by its reported use on alkaline soils.

20612 (G. I. No. 261); also 24995. *Manchu Brown* (fig. 12). Received from Manchuria through Prof. N. E. Hansen, Agricultural Explorer, March, 1907.

(No. 92) *Gaolan*. Brought by a Russian student-soldier from Manchuria after the Russo-Japanese War. (Hansen.)

Grown at Amarillo, Tex., in 1907. Plants slender, 1.2 to 1.8 meters (4 to 6 feet) in height; leaves small, 7 to 10; panicles small to medium, sparse, of light weight, narrowly ovate or conical, 1.5 to 2.5 dm. (6 to 10 inches) in length, the lower branches 5 to 10 cm. (2 to 4 inches) long; spikelets 5 to 6 mm. long; glumes black, shining; seeds oval or obovate oval, 4 to 5.5 mm. long by 3 to 4 mm. wide, burnt umber to raw umber to buff, one-fourth exerted. A low and extra-early variety, maturing in 85 to 95 days, the earliest of any introduction yet tested. It is proving of value in extending the cultivation of this crop to South Dakota and other Northern and North-western States.

20620 (G. I. No. 262). *Manchu Brown* (?). Received from Usuri Province, Siberia, through Prof. N. E. Hansen, Agricultural Explorer, March, 1907.

(No. 100) *Gaolan*. This variety grows from 20 to 25 feet in height, and during the Russo-Japanese war the Cossacks on horseback found trouble in getting through the sorghum fields, as they would be lost from view even with their spears. (Hansen.)

Planted at Amarillo, Tex., in 1907, but no seed germinated. Plant not known and identification doubtful; spikelets 4 to 5.5 mm.; glumes chestnut to maroon, shining; seeds obovate or obovate oval, 4.5 mm. long by 3 to 3.8 mm. wide, walnut brown to bay.

20621 (G. I. No. 263). *Paperhull*. Source same as for No. 20620.

(No. 101) *Golan*. For description see No. 100 (S. P. I. No. 20620). The head does not appear as compact as in No. 100. Seed brought from Manchuria by a Russian student-soldier after the Russo-Japanese war. (Hansen.)

Grown at Amarillo, Tex., in 1907, and again in 1908. Plants 1.5 to 2 meters (5 to 6.5 feet) in height; leaves 6 to 8; panicle ovate or ovate conical, sparse, lax, of light weight; spikelets 4.5 to 5.5 mm. long; glumes thin, papery, black, shining, equaling the seed; seeds narrowly oval, 4 to 5 mm. long by 2.5 to 3 mm. wide, burnt umber,



FIG. 12.—Field of an extra-early variety of Manchu Brown kaoliang (G. I. No. 261, S. P. I. No. 20612), Amarillo, Tex., August 20, 1908. (Photographed by C. R. Ball.)

included. A low variety of extra-early to early maturity, ripening in 85 to 95 days; heads, however, of poor quality and the variety discarded.

20627 (G. I. No. 264). *Manchu Brown*(?). Source same as for No. 20612.

(No. 107) Native name, *Tjie-choo-meed-zha*. This variety is used for brooms in Manchuria. Seed brought from Manchuria by a Russian student-soldier after the Russo-Japanese war. (Hansen.)

Planted at Amarillo, Tex., in 1907, but no seed germinated. Plant not known and identification doubtful; spikelets 4.5 to 5.5 mm. long; glumes maroon to black with buff trimmings; seeds obovate oval, 4 to 4.5 mm. long by 3 to 3.5 mm. wide, walnut brown to chocolate.

20706 (G. I. No. 265). *Baird Brush* (?). Received from the southern part of the Pacific coast section of Usuri Province, Siberia, through Prof. N. E. Hansen, Agricultural Explorer, March, 1907.

"(No. 186) *Gaolan*." (*Hansen*.)

Grown at Amarillo, Tex., in 1907, when only a single seed germinated, and again in 1908. Plant 1.5 to 1.8 meters (5 to 6 feet) in height; leaves 7 to 8; panicles narrowly ovate or conical, small, lax; poorer than those of No. 20621 and much inferior to those of No. 20612; the very immature original sample has spikelets 4.5 to 5 mm. long; glumes buff to coral to madder brown; seeds too shrunken for accurate measurement; apparently no home-grown samples preserved. A low and early variety, ripening in 85 to 95 days; of no value.

21077 (G. I. No. 272). *Mukden White* (see fig. 14, d). Received from Mukden, Manchuria, through Mr. Frank N. Meyer, June 21, 1907.

(No. 717, a, January 23, 1907.) A white sorghum; Chinese name, *Pai kau liang*. The best variety of white millet grown around Mukden. It is used as a food in the form of porridge, small cakes, and also served often as vermicelli. It commands one-third more money than the brown-colored millets do. (*Meyer*.)

Grown at Chillicothe, Tex., in 1907, and at Amarillo, Tex., Hays, Kans., Akron, Colo., Bellefourche, S. Dak., and Dickinson, N. Dak., in 1908. Plants 1.8 to 2.4 meters (6 to 8 feet) in height; leaves 9 to 11; panicles large, oval to conical, lax, 2.2 to 3 dm. (9 to 12 inches) in length; spikelets oval, 4 to 5 mm. long; glumes 3 to 4 mm. long, mostly buff, rarely shaded; seeds oval to obovate oval, 4 to 4.5 mm. long by 3 to 3.5 mm. wide, one-fourth to one-third exserted. A variety of medium height and of medium-early to medium-late maturity, ripening in 95 to 115 days; panicles less desirable than those of No. 17920.

21078 (G. I. No. 273). *Valley Brown* (fig. 14, a). Source same as for No. 21077.

(No. 718, a, January 23, 1907.) A brown-colored sorghum; Chinese name *kau liang*. The best variety of brown millet grown around Mukden. It is used as a food in the shape of porridge and cakes; also an important food for the domestic animals. (*Meyer*.)

The record for this introduction is a duplicate of that for No. 21077. They were introduced, distributed, and tested together and gave identical results, the chief difference apparent in the field being in the color of the seeds; spikelets 4.5 to 5.7 mm. long; glumes buff to burnt sienna; seeds oval, broadly oval or obovate, 3.5 to 5.2 mm. long by 2.5 to 3.5 mm. wide, clay to burnt sienna, one-fourth exserted.

21676 (G. I. No. 276). *Ichang Brown*. Received from Ichang, Hupeh, China, through Mr. E. H. Wilson, collector for the Arnold Arboretum, Jamaica Plain, Mass., in November and December, 1907.

(No. 260.) A cereal growing 6 to 12 feet high. Pellicles reddish black. Cultivated in the valleys and low hills to the south of Ichang. (*Wilson*.)

Grown at Amarillo, Tex., in 1911. A description will be found in the classification. A variety of medium height and medium maturity, ripening in 110 days in the season tested.

The original sample contained some smaller spikelets with glumes gibbous at the base and transversely ridged, orange vermilion in color, apparently the same as those comprising most of No. 21677. When grown, the resulting plants were essentially Tokyo Brown, the variety represented by the above number, which is discussed below.

21677 (G. I. No. 277). *Tokyo Brown* (Pl. II, P). The source is the same as for No. 21676.

(No. 260, a.) A cereal growing 6 to 12 feet high. Pellicles black or nearly so. Commonly cultivated in the valleys around Ichang. (*Wilson*.)

Grown at Amarillo, Tex., in 1911. Plants 1.3 to 1.7 meters (4.5 to 5.5 feet) in height, with stout culms, 2.2 to 2.7 cm. (0.9 to 1.2 inches) in butt diameter; leaves 11 to 12 in number, 0.85 to 1 dm. (3.5 to 4 inches) wide, 7.5 to 8.1 dm. (2.5 to 2.7 feet) long; panicles large, conical, lax, 3 to 3.7 dm. (12 to 15 inches) in length, exerted 5 cm. (2 inches) or less, lower branches 1 to 2 dm. (4 to 8 inches) long; spikelets small, broadly ovate, 3 mm. wide in one plane, 4 mm. wide in the other, and 4 mm. long; glumes gibbous at the base, transversely shouldered above the center, apex depressed and appressed to the seed, cinnamon, cream, and clay to claret brown and black; seeds broadly obovate to sublenticular, 3 to 3.5 mm. wide by 4 mm. long, russet to burnt umber in the original seed, cream to raw sienna and burnt sienna in the Amarillo seed. A low variety of medium maturity, ripening in 110 days in the single test so far made. The original was a mixture of two varieties, the one described below and one with normal glumes, practically identical with Tokyo Brown, G. I. No. 276, from the same source.

21678 (G. I. No. 278). *Shasi Brown* (Pl. II, M). Source same as for No. 21676.

(No. 202.) A cereal growing 8 to 12 feet high. Pellicles dull red or reddish chestnut. Widely cultivated on the alluvial flats between Shasi and Yochow, and more especially around Shasi. It was from the last-named place that the seeds were obtained. In this part of the Yangtze Valley the sole use of sorghum (kaoliang) is for making wine and spirits. I can find no record of its being used for food even, by the peasants. (Wilson.)

Grown at Amarillo, Tex., in 1911. A description will be found in the chapter on classification. A variety of medium stature and maturity, ripening in 110 days in the single test made.

22010 (G. I. No. 293). *Shantung Dwarf* (fig. 13; fig. 14, b; Pl. II, R). Received from Chingshan, Shantung, China, at the Plant Introduction Garden, Chico, Cal., through Mr. Frank N. Meyer, February 12, 1908.

(No. 810, a, August 12, 1907.) Chinese name, *Chi tse ya tse*. A very rare dwarf variety of sorghum, not growing higher than 3 feet and making dense heads. Grows on shallow sterile soils and matures much earlier than the taller growing varieties. May do well in the semiarid regions of the western United States. (Meyer.)

Grown at Amarillo, Tex., in 1908, and continuously there and at other points thereafter. Description will be found under this variety in the classification. A very dwarf variety of medium-early maturity, ripening in 105 to 110 days.

22011 (G. I. No. 327). *Redstem*. Received from near Chufuo (Tsou¹), Shantung, China, at the Plant Introduction Garden, Chico, Cal., through Mr. Frank N. Meyer, February 12, 1908.

(No. 811, a, September 7, 1907.) A red-stemmed variety used in the manufacture of matings, of which pretty specimens may be seen once in a while. (Meyer.)

Grown at Chico, Cal., in 1908, but no record is available. Grown at Amarillo, Tex., in 1909, and thereafter. A description will be found under this variety in the classification. A low to medium variety of early maturity, ripening in about 95 days; strikingly characterized by the reddish stems.

22012. Variety not determined. Received from near Chungdun, Shantung, China; otherwise same as No. 22010.

(No. 812, a, September 29, 1907.) A very tall-growing loose-headed variety of sorghum. The thrashed-out heads are utilized in broom manufacture. Stands alkali well. (Meyer.)

Not grown by the writer and a description of the plant is not available; panicle sparse, lax, narrowly ovate conical, 4 dm. (16 inches) in length, somewhat resembling

¹ Mr. S. C. Stuntz, of the Office of Foreign Seed and Plant Introduction, identifies the Chufuo of Mr. Meyer's notes as Tsou, the suffix "foo" or "fu" merely denoting a town of certain official rank.

that of Minnesota Amber sorgo; branches 1.5 to 2 dm. (6 to 8 inches) long; rachis continuous; spikelets obovate oval, 5 to 5.5 mm. long; glumes 4.5 to 5 mm. long, subglaucous, smoke gray or heliotrope; seeds oval, 4.5 to 5 mm. long by 3 to 3.5 mm. wide, clay to burnt umber.

22911 (G. I. No. 309). *Valley Brown* (fig. 14, c; Pl. II, J.). From Tsungming Island, China. Obtained through Rev. J. Ware and presented by Dr. S. P. Barchet, interpreter, American consulate, Shanghai, China. Received May 20, 1908.

Grown at Amarillo, Tex., in 1908. Plant 1.8 meters (6 feet) in height and stoutish, 2 to 2.5 cm. (1 inch) in butt diameter; leaves 8 to 10 in number, 7.5 to 8.5 dm. (3 to 3.5 inches) wide, 6 to 6.5 dm. (2 to 2.2 feet) long; panicles oval, lax, heavy, 2 to 3 dm. (8 to 12 inches) long and 1 to 2 dm. (4 to 8 inches) wide, well exerted; spikelets 4 to 5.5



FIG. 13.—Plants of Shantung Dwarf Brown kaoliang (G. I. No. 293, S. P. I. No. 22010) in the foreground and the ordinary taller variety behind it, Chingshan, Shantung, China, August 12, 1907. (Photographed by Frank N. Meyer.)

mm. long; glumes mostly buff or clay, shading to cardinal and maroon; seeds broadly obovate oval to sublenticular or subspherical, being less flattened than most, 3.5 to 5 mm. long by 2.6 to 4 mm. wide, clay to walnut brown in the original sample, cream to russet to burnt umber in later years. A low to medium variety, early to medium-early in maturity, ripening in 100 to 105 days; of considerable promise as a grain producer.

22912 (G. I. No. 310). *Barchet Blackhull* (fig. 15; Pl. II, C). From Tsungming Island, China. Obtained through Rev. J. Ware and presented by Dr. S. P. Barchet, interpreter, American consulate, Shanghai, China. Received May 20, 1908.

The white variety (S. P. I. No. 22912) is considered inferior to the red (S. P. I. No. 22911, Brown), though planted in the same way. It is planted in richly manured

land in rows 6 inches wide covered lightly with half an inch of earth. If plants come up too thick or crowded, the plants which should be removed are not pulled, but cut off with a sharp knife, so as not to disturb the roots of neighboring plants. (Barchet.)

Grown at Amarillo, Tex., in 1908, and thereafter. A description will be found under this variety in the classification. A low variety of early to medium-early maturity, ripening in 100 to 105 days; unfortunately allowed to hybridize with a brown-seeded variety in 1908, the crop of 1909 containing 50 per cent or more of hybrids. A pure strain has been isolated and is likely to prove one of the most valuable of the introductions.

23230 (G. I. No. 323). *Chusan Brown*. Received from Chusan Islands, Chekiang, China, through Mr. Frank N. Meyer, Agricultural Explorer, and brought by him to



Fig. 14.—Rows of five varieties of kaoliang, Amarillo, Tex., August 20, 1908: *a*, Valley Brown (G. I. No. 273, S. P. I. No. 21078); *b*, Shantung Dwarf Brown (G. I. No. 293, S. P. I. No. 22010); *c*, Valley Brown (G. I. No. 309, S. P. I. No. 22911); *d*, Mukden White (G. I. No. 272, S. P. I. No. 21077); *e*, Barchet Black-hull (G. I. No. 310, S. P. I. No. 22912.)

the Plant Introduction Garden, Chico, Cal., June, 1908. Forwarded to Washington, D. C., and received July 6, 1908.

(No. 983, *a*, April, 1908.) A tall-growing variety of sorghum, coming from the Chusan Islands, called *Chang tsun*. Obtained from Dr. S. P. Barchet at Shanghai, China. (Meyer.)

Grown at Amarillo, Tex., in 1909, where only 13 seeds germinated, each producing two stalks. No description of the plant is available; glumes short, chestnut to bay, shining; seeds broadly ovate or sublenticular, 3 to 4 mm. long by 2.5 to 3.5 mm. wide, chocolate to burnt umber to bay.

23231 (G. I. No. 324). *Chusan Brown* (Pl. II, O). Source same as for No. 23230.

(No. 984, *a*, April, 1908.) A dwarfy form of a sorghum, coming from the Chusan Islands, called *Tuan tsun*. Obtained from Dr. S. P. Barchet at Shanghai, China. (Meyer.)

Grown at Amarillo, Tex., in 1909, 1910, and 1911, only 54 seeds germinating in the first year. Plants 1.3 to 2 meters (4.5 to 6.5 feet) in height, mostly without suckers; leaves 9 to 11 in number, 0.8 to 1 dm. (3.2 to 4 inches) wide, 6.5 to 7.5 dm. (2.2 to 2.5

feet) long; panicles small, compact, 1.4 to 1.8 dm. (5.5 to 7.5 inches) long; lower branches only 5 to 9 cm. in length, seeded to the base; rachis continuous; spikelets 3.5 to 4 mm. long; glumes brick red to maroon and darker, shining; seeds broadly obovate to sublenticular, 3 to 4 mm. long by 2.8 to 3.2 mm. wide, walnut brown to bay in original sample; clay to raw sienna to bay. A low variety of medium maturity, ripening in about 110 days in 1910 and 1911.



FIG. 15.—Plat of Barchet Blackhull kaoliang (G. I. No. 310, S. P. I. No. 22912), grown at Dalhart, Tex., 1911; height, 4½ feet. (Photographed by C. R. Ball.)

24478 (G. I. No. 328). *Manchu Brown*. Received from Manchuria, through Prof. N. E. Hansen, Agricultural Explorer, December 3, 1908.

(No. 85.) Variety *Gaolan* from the Harbin district, bought in a Chinese bazaar at Station Manchuria, the first station in Chinese territory going east on the Siberian Railway. The favorite variety in northern Manchuria. (*Hansen.*)

Grown at Amarillo, Tex., in 1909, and thereafter. Plants 1.4 to 1.8 meters (4.5 to 6 feet) in height, with no suckers and an average of 10 leaves; panicles oval, 2 to 2.7 dm. (8 to 11 inches) in length, lower branches 5 to 10 cm. (2 to 4 inches) long, rachis

continuous; spikelets 4.5 to 5 mm. long; glumes black, shining; seeds obovate, oval, or a few broadly obovate, 4 to 5 mm. long by 3 to 3.7 mm. wide, burnt umber with chocolate tips. A low, extra-early to early variety, ripening in 80 to 90 days.

24990 (G. I. No. 122). *Peesan Brown*.

Grown on the experiment farm at Amarillo, Tex., by Mr. John F. Roes, season of 1908. Received March, 1909.

Improved by selection for dwarf stature, productiveness, etc., from S. P. I No. 17922, by Mr. Carleton R. Ball.

24991 (G. I. No. 123). *Tientsin Brown*.

Grown as was No. 24990. Improved at the last by selection from No. 17923.

24992 (G. I. No. 171, A). *Manchu Brown*.

Grown as was No. 24990. Improved at the last by selection from No. 18518.

24993 (G. I. No. 171, B). *Manchu Brown*. Record the same as for No. 24992.

24994 (G. I. No. 171, C). *Manchu Brown*. Record the same as for No. 24992.

24995 (G. I. No. 261). *Manchu Brown*. Grown as was No. 24990.

Improved by Mr. Carleton R. Ball, by selection from No. 20612.

27553 (G. I. No. 412). *Korean Blackhull* (Pl. II, B). Received from Choon Chun, Chosen (Korea) April 4, 1910, through Mr. J. Robert Moose.

Grown at Amarillo, Tex., in 1910 and 1911. A description will be found under this variety in the classification. A tall, medium-early variety with large ovate-conical heads, maturing in 103 and 108 days in the two seasons tested.

27554 (G. I. No. 413). *Choonchun Brown* (Pl. II, Q). Source same as for 27553.

Grown at Amarillo, Tex., in 1910 and 1911. A description will be found under this variety in the classification. A low variety of medium-early maturity, ripening in 103 and 98 days in the two seasons grown; not promising.

27555 (G. I. No. 414). *Moose Brown*. Source same as for 27553.

Grown at Amarillo, Tex., in 1910 and 1911. A description will be found in the classification. A variety of medium height and of medium-late maturity, ripening in 114 and 120 days in the two seasons tested.

28027 (G. I. No. 421). *Ware Brown* (Pl. II, K). Received from Tsungming Island, Chekiang, China, May 20, 1910. Secured by Rev. James Ware, of the Foreign Christian Missionary Society, Shanghai, China, and forwarded through Mr. Amos P. Wilder, American consul general.

Kowliang. Said to be the finest variety on the island. Tsungming is an alluvial island in the estuary of the Yangtze River. It lies between 31° and 32° north latitude. Prevailing winds from southeast. Total length from east to west 60 miles; average breadth 12 miles. The soil is rich except at the northwest corner, where it is overcharged with alkali. Population, including small islands around and a few towns on the north mainland, 1,200,000. (*Ware*.)

Grown at Amarillo, Tex., in 1910 and 1911. A description will be found in the classification. A medium-low and early to medium-early variety, ripening in 92 days in 1910 and in 92 to 110 days in 1911.

28057 (G. I. No. 423). *Valley Brown*. Received from Mukden, Manchuria, June 2, 1910. Produced by Mr. Edward C. Parker, agriculturist, Bureau of Agriculture, Industry, and Commerce, Mukden, Manchuria.

High stalk, spreading panicle. Chinese name, *Sungma kaoliang*. This plant is the chief and characteristic crop of Manchuria. Its seeds are the every-day food of most of the common people, as well as the chief food of the farm animals. The leaves are stripped off the plant for live-stock food, and the stalks are burned to boil the water and heat the mud houses for all Manchuria. This sample of seed comes from

Mukden, Manchuria, 42° north latitude, and is of a tall-growing variety with open or spreading panicle. This tall kaoliang thrives best in latitude 38° to 42° north, maturing usually in October and requiring a late autumn to properly mature. It withstands drought and hot, drying winds better than maize and will also stand an excess of moisture better than maize. The stalks are fibrous and rigid and do not lodge under stress as easily as maize. (*Parker*.)

Grown at Amarillo, Tex., in 1910 and 1911. Plants 2.1 to 2.7 meters (7 to 9 feet), slender to medium in diameter; leaves 9 to 10 in number, 0.7 to 0.9 dm. (2.7 to 3.5 inches) wide, 6 to 6.7 dm. (2 to 2.2 feet) long; panicle very lax, oval or subconical or sometimes nearly one-sided, large, 2.5 to 3.5 dm. (10 to 14 inches) in length, exerted 0.7 to 1.5 dm. (3 to 6 inches), with lower branches 1.2 to 2 dm. (5 to 8 inches) long, and upper branches 1 to 1.2 dm. (4 to 5 inches) or longer; the rachis one-half to three-fourths as long as the panicle; spikelets 4.5 to 5 mm. long; glumes buff to clay to hazel to brick red; seeds oval to obovate, 4 to 4.8 mm. long by 3 to 3.5 mm. wide, cream to orange buff, russet and madder brown, in 1910 white, buff, hazel, and brick red, in 1911 buff to chestnut, one-sixth exerted. A medium-early variety of medium height, ripening in 99 and 110 days in the two seasons tested.

28058 (G. I. No. 424). *Parker Brown* (Pl. II, L). Source same as for 28057.

Short stalk, compact panicle. Chinese name, *Chinma kaoliang*. This species matures somewhat earlier than the tall variety (S. P. I. No. 28057) and is grown commonly in Manchuria north of 42° north latitude. This sample comes from Mukden, Manchuria. Usage same as No. 28057. (*Parker*.)

Grown at Amarillo, Tex., in 1910 and 1911. A description will be found in the classification. A variety of medium height and early maturity, ripening in 92 and 96 days in the two seasons tested.

CLASSIFICATION OF THE KAOLIANGS.

DESCRIPTION OF THE GROUP.

The extensive varietal study which has been conducted with these introductions makes it possible to characterize the group of kaoliangs with some accuracy. From the foregoing descriptions of the various introductions it becomes apparent that there is much diversity of habit, color, etc., among the various varieties. Nevertheless, they have certain characters in common. Among these common characters are dry, pithy, and rather slender stalks, usually only 1 to 3 cm. in butt diameter, bearing relatively few (8 to 11 or sometimes 13) leaves which are comparatively small, 1 to 2.5 feet long and 1 to 2.5 inches wide; glumes never exceeding the seed, almost wholly glabrous, and lemmas always awned.

The rachis and panicle branches are more or less scabrous, but not pubescent except on and around the pulvini or swollen bases of the panicle branches. The sterile spikelets are 3 to 4 mm. long and narrowly lanceolate or elliptical, consisting of the outer glumes. The awn of the lemma is universally present, 2 to 5 mm. long, twisted, and geniculate in the middle.

In habit the kaoliangs vary from 0.7 to 3.6 meters in height, the panicles varying from small, oval, and compact to long, umbelliform,

and lax. The glumes vary from gibbous at the base, transversely ridged above the center with depressed and closely appressed apex to thin, flat, and chartaceous; from one-half or two-thirds as long as the seeds to equaling them; from cream or cream buff through various shades of red and brown to black. The seeds also vary in size from 3 to 6 mm. long; in shape from narrowly oval to sub-lenticular, and in color from chalky white through buff and orange buff to various shades of reddish brown and brown. So far as known all are susceptible to the kernel smut (*Sphacelotheca reiliana*). Almost all lots of seed imported are infected with this disease.

It may be contended that the varieties having glumes gibbous at the base, transversely ridged above the center, and the apices depressed and closely appressed to the seed should really be placed in a group separate from the kaoliangs. These glume characters indicate durra affinities and it is probable that their original Indian progenitors were less widely separated from the durras. In the long time, probably centuries, however, which has elapsed since their introduction to China, they have varied in the same directions as the more typical kaoliangs.

Twenty-seven varieties of kaoliang are described in this paper. Five of these are in the white-seeded section of the group and 22 in the section with brown seeds. Of the 5 varieties having white seeds, 3 fall in the subsection having black glumes and 2 in the subsection with buff glumes. Of the 22 varieties in the brown-seeded section, 8 occur in the black-glumed subsection and 14 in that with buff to red glumes. These 27 varieties include 58 of the 59 separate introductions and accessions described. The remaining one is a recent introduction, which is described but not identified for lack of sufficient data.

KEY TO THE VARIETIES.

I. Seeds white, dirty white, or cream.

A. Glumes black, shining.

1. Seeds white, narrowly oval to oval.

- a. Panicles large, lax, oval or subumbelliform, 9 to 14 inches long; plants 8 to 12 feet tall, late.

Brill Blackhull [Agrost. No. 1442; S. P. I. Nos. 6710 (Agrost. No. 1457), 17920 (G. I. No. 120)].

2. Seeds dirty white, obovate or sublenticular.

- a. Panicle lax, ovate or ovate conical or one-sided, often nodding, 8 to 12 inches long; plants 6 to 8 feet tall, medium early.

Korean Blackhull [S. P. I. No. 27553 (G. I. No. 412)].

- b. Panicle semicompact, oval, 7 to 10 inches, erect; plants 5 to 6 feet, medium early.

Barchet Blackhull [S. P. I. No. 22912 (G. I. No. 310)].

I. Seeds white, dirty white, or cream—Continued.

B. Glumes buff, often shading to orange buff or orange vermillion.

1. Seeds white, oval or obovate oval.

- a. Panicle lax, oval or ovate, large, 8 to 12 inches long; plants 6 to 10 feet tall, medium early.

Mukden White [Agrost. No. 1443; S. P. I. Nos. 18610 (G. I. No. 190), 21077 (G. I. No. 272)].

2. Seeds cream, obovate to sublenticular.

- a. Panicle lax, elongated, umbelliform, 12 to 15 inches long.

Headlands Brush [S. P. I. No. 18613].

II. Seeds brown or reddish brown.

A. Glumes black, shining.

1. Glumes equaling the seed.

- a. Glumes coriaceous; panicle umbelliform; plants 6 to 8 feet tall, medium late.

Hoki Brown [Agrost. No. 1585].

- b. Glumes thin, papery; inflorescence paniculate; plants 5 to 6 feet tall, early.

Paperhull Brown [Agrost. No. 1584; S. P. I. No. 20621 (G. I. No. 263)].

2. Glumes shorter than the seed.

- a. Seeds medium to large, oval to obovate oval; panicle medium to large, lax, 8 to 14 inches long.

- * Panicle lax, large, 8 to 14 inches long, broadly oval; plants 7 to 10 feet tall, late in maturity.

Hansen Brown [Agrost. No. 1444; S. P. I. Nos. 225, 3863 (Agrost. No. 1448), 6604 (Agrost. No. 1455 in part), 17921 (G. I. No. 121)].

- ** Panicle lax, large, coarse, 9 to 14 inches long, oval or obovate oval, naked at base; plants 7 to 8.5 feet tall, medium in maturity (105 to 120 days).

Tientsin Brown [S. P. I. Nos. 17923 (G. I. No. 123), 24991].

- *** Panicle finer, sparse, narrowly oval to cylindrical, 8 to 12 inches long; plant 6 to 8 feet tall, medium-late maturity (115 to 120 days).

Meyer Brown [S. P. I. Nos. 6411 (Agrost. No. 1454), 18625].

- **** Panicle small to medium, semicompact, oval, 8 to 10 inches long.

△ Plant 5 to 8 feet tall, medium early, (100 to 110 days).

Kali Brown [S. P. I. No. 19187 (G. I. No. 193)].

△△ Plant 4.5 to 7 feet tall, extra early to early (85 to 100 days).

Manchu Brown [S. P. I. Nos. 939, 18518 (G. I. No. 171), 18611 (G. I. No. 191), 18612 (G. I. No. 192), 20612 (G. I. No. 261), 20620 (G. I. No. 262), 20627 (G. I. No. 264), 24478 (G. I. No. 328), 24992 to 24994 (G. I. No. 171), 24995 (G. I. No. 261)].

- b. Seeds small, broadly obovate or sublenticular.

- * Panicle small, slender, oblong, semicompact, 8 to 11 inches long.

Hankow Brown [S. P. I. No. 6604 in part (Agrost. No. 1455) (Kans. Exp. Sta. No. 595) (G. I. No. 326)].

II. Seeds brown or reddish brown—Continued.

B. Glumes buff to various shades of red.

1. Glume I flat, glume II keeled, not gibbous or ridged.

a. Inflorescence umbelliform, rachis shortened.

* Panicle medium (9 to 11 inches); branches shorter.

Chihli Brush [S. P. I. No. 18626].

** Panicle elongated (12 to 18 inches), branches equaling the panicle.

Baird Brush [S. P. I. Nos. 6406 (Agrost. No. 1453), 18614, 20706 (?) (G. I. No. 265)].

b. Inflorescence paniculate; oval, ovate or conical.

* Panicle broadly oval, lax, heavy, 2.5 to 3.3 dm. (10 to 14 inches) long; rachis somewhat shortened, upper branches 1 to 1.2 dm. (4 to 5 inches) long, more than half as long as the lower; color effect light brown.

△ Seeds large, broadly obovate or oval to sublenticular; glumes buff to cardinal and maroon.

Valley Brown [S. P. I. Nos. 16792 (G. I. No. 152), 21078 (G. I. No. 273), 22911 (G. I. No. 309), 28057 (G. I. No. 423)].

△△ Seeds large, oval to obovate; glumes paler.

Moose Brown [S. P. I. No. 27555 (G. I. No. 414)].

** Panicle conical, lax, heavy, 2.5 to 3.5 dm. (10 to 14 inches) long; upper branches 5 to 7 cm. (2 to 2.8 inches) long; rachis nearly equaling panicle.

△ Glumes, especially glume I, exceeding the seed, 5 to 6 mm. long.

Ware Brown [S. P. I. No. 28027 (G. I. No. 421)].

△△ Glumes equaling or, especially glume II, shorter than the seed, 4 to 5 mm. long.

+ Peduncles red.

Redstem [S. P. I. No. 22011 (G. I. No. 327)].

++ Peduncles straw color.

○ Lower panicle branches 1.2 to 1.6 dm. (5 to 6.5 inches) long.

† Branches stout, rigid; seeds acute.

Parker Brown [S. P. I. No. 28058 (G. I. No. 424)].

†† Branches slender, flexible; seeds obtuse.

= Seeds elliptical or narrowly oval.

Shasi Brown [S. P. I. No. 21678 (G. I. No. 278)].

== Seeds broadly oval to sublenticular.

Peesan Brown [S. P. I. Nos. 17922 (G. I. No. 122); 24990].

○○ Lower panicle branches 0.5 to 1 dm. (2 to 4 inches) long.

Ichang Brown [S. P. I. No. 21676 (G. I. No. 276)].

*** Panicle small, oval, compact, 3 to 6 inches long; seeds small, broadly obovate to sublenticular.

Chusan Brown [S. P. I. Nos. 23230 (G. I. No. 323), 23231 (G. I. No. 324)].

II. Seeds brown or reddish brown—Continued.

B. Glumes buff to various shades of red—Continued.

2. Glumes gibbous at the base, transversely ridged above the middle, with depressed apex.

a. Spikelets small, broadly obovate to sublenticular; panicle large, lax; plants medium height.

Tokyo Brown: [Agrost. Nos. 1576, 1586; S. P. I. Nos. 4905, 21677 (G. I. No. 277)].

b. Spikelets medium to large, oval; panicle small to medium, compact.

* Plant medium; spikelets medium; panicle small, slender.

Choonchun Brown [S. P. I. No. 27554 (G. I. No. 413)].

** Plant very dwarf; panicle heavy, compact, oval; spikelets large.

Shantung Dwarf [S. P. I. No. 22010 (G. I. No. 293)].

DESCRIPTION OF THE VARIETIES.

In the white-seeded section of the kaoliang group five varieties have been distinguished, three in the subsection having black hulls and two in the one having buff hulls. These varieties may be separated and described as follows:

I. *Seeds white, dirty white, or cream.*A. *Glumes black and shining.*1. *Seeds white, narrowly oval to oval.*

Brill Blackhull. Agrost. No. 1442; S. P. I. Nos. 6710 (Agrost. No. 1457), 17920 (G. I. No. 120) (Pl. II, A). Plants 2.4 to 3.6 meters (8 to 12 feet) tall, bearing 10 to 13 leaves and 1 to 3 suckers each; panicles large, erect, lax, much branched, not always fully exerted, 2.3 to 3.5 dm. (9 to 14 inches) long, and 1 to 1.5 dm. (4 to 6 inches) wide, with rachis one-half to two-thirds as long as the panicle and about equaling the basal branches; spikelets 5 to 7 mm. long; seeds chalky to dirty white, narrowly oval, 4 to 6 mm. long, 3 to 4 mm. wide, covered for three-fourths of their length by the shining black glumes.

A tall, late variety with large open heads, maturing in 120 to 140 days, too tall and late for profitable use. Continued selection for earliness has given but little result so far. It is comparable to Hansen Brown among the brown varieties.

2. *Seeds dirty white, obovate or sublenticular.*a. *Panicles large, lax, ovate conical, or one-sided.*

Korean Blackhull. S. P. I. No. 27553 (G. I. No. 412) (Pl. II, B). Plants 1.8 to 2.4 meters (6 to 8 feet) tall, stoutish, 2.5 to 3 cm. (1 to 1.2 inches) in butt diameter, bearing 10 to 11 leaves; panicle large, lax, ovate conical or one sided, and forming a right-angled triangle, 2.5 to 3.7 dm. (10 to 15 inches) long, often nodding at maturity; lower branches 1.2 to 2.2 dm. (5 to 9 inches) long; spikelets 4 to 4.5 mm. long; seeds 3.5 to 4 mm. long, 3 to 3.5 mm. wide, obovate or sublenticular, dirty white, three-fourths inclosed by the shining black glumes.

A tall medium-early variety with large ovate-conical heads, maturing in 103 and 108 days in the two seasons tested.

b. *Panicles medium size, semicompact, oval.*

Barchet Blackhull. S. P. I. No. 22912 (G. I. No. 310) (Pl. II, C; fig. 14, c; fig. 15). Plants 1.3 to 1.6 meters (4.5 to 6 feet) tall, 1.5 to 3 cm. in butt diameter, bearing 8 to 9 leaves; panicle spreading or semicompact, oval or ovate oval, 2 to 2.5 dm. (8 to

10 inches) long, heavy (averaging 3 ounces each), fairly exserted; spikelets 4 to 4.5 mm. long; seeds dirty white, broadly obovate or sublenticular, 3.5 to 4 mm. long, 3 to 3.6 mm. wide, broader in proportion than those of any other white-seeded form; glumes black and shining, covering two-thirds of the seed.

A low, medium-early variety with oval heads, averaging 2 to 2.7 ounces each in different seasons, maturing in 100 days in 1908 and in 105 to 110 in later seasons, classing it as medium early.

B. *Glumes buff, often shading to orange buff or orange vermillion.*

1. *Seeds white, oval or obovate oval.*

a. *Panicles lax, oval or semipyramidal, large.*

Mukden White. Agrost. No. 1443; S. P. I. Nos. 18610 (G. I. No. 190), 21077 (G. I. No. 272) (Pl. II, D; fig. 11; fig. 14, d). Plants 1.8 to 3 meters (6 to 10 feet) tall, bearing 9 to 11 leaves and usually no suckers; panicles lax, oval or subconical, large, 2 to 3 dm. (8 to 12 inches) long, with a nearly continuous rachis and the basal branches 1 to 1.5 dm. (4 to 6 inches) long; spikelets 4 to 6 mm. long, broadly oval; seeds 4 to 5 mm. long by 3 to 3.5 mm. wide, oval or obovate oval, white, exserted about one-third of their length; glumes 3 to 4 mm. long, firm, buff to orange buff and orange vermillion.

2. *Seeds cream colored, obovate to sublenticular.*

a. *Panicle lax, elongated, umbelliform.*

Headlands Brush. S. P. I. No. 18613. Plant not known; original panicle lax, elongated, umbelliform, 3.2 dm. (13 inches) long, probably nodding, the rachis 8 cm. (3 inches) long, bearing 4 whorls of branches; spikelets 4 to 4.5 mm. long, sublenticular, seeds 3.5 to 4 mm. long, 3 to 3.5 mm. wide, broadly obovate to sublenticular, cream colored; slightly exserted; glumes cream colored, shining, covering four-fifths to all of the seed.

Sixteen varieties are found in the section with brown seeds. Seven of these occur in the subsection having black glumes and 14 in the subsection having the glumes varying from buff to different shades of red.

II. *Seeds brown or reddish brown.*

A. *Glumes black, shining.*

1. *Glumes equaling the seeds.*

a. *Glumes firm; panicle umbelliform, 12 inches long; plants 6 to 8 feet tall, medium late.*

Hoki Brown. Agrost. No. 1585. Plants 1.8 to 2.4 meters (6 to 8 feet) tall; panicle umbelliform, slender, 3 dm. (12 inches) long, becoming reflexed and nodding; branches mostly basal, elongated; rachis, however, extended, its first internode several inches long, bearing terminal whorls of short branches from the second and third nodes; spikelets black, obovate, 4.2 to 5 mm. long; glumes black, shining; seeds obovate oval, 3.7 to 4.3 mm. by 2.8 to 3.5 mm., russet to burnt umber.

A broom-corn type of medium height, heading in 90 days, ripening probably in 120 days, and therefore medium late. Possibly a degenerate form of a true broom corn introduced into Japan from Europe or America.

b. *Glumes thin, papery; inflorescence paniculate; plants 5 to 6 feet tall, early.*

Paperhull. Agrost. No. 1584; S. P. I. No. 20621 (G. I. No. 263). Plants 1.5 to 2 meters (5 to 6.5 feet) tall, bearing 6 to 8 leaves; panicles sparse, ovate or elliptical, 1.5 to 2.5 dm. (6 to 10 inches) long; spikelets oval, 4.5 to 5.5 mm. long; glumes black,

shining, as long as the seeds, thin, chartaceous or papery in texture; seeds oval or narrowly oval, 4 to 5 mm. by 2.5 to 3 mm., russet to burnt umber.

A rather low variety, extra early to early, maturing in 85 to 95 or 100 days. The name was suggested by the character of the glumes.

2. *Glumes shorter than the seed.*

a. *Seeds medium to large, oval to obovate oval; panicle medium to large, lax, 7 to 14 inches long.*

* *Panicle lax, large, 8 to 14 inches long, broadly oval; plants 7 to 10 feet tall, late in maturity.*

Hansen Brown. Agrost. No. 1444; S. P. I. Nos. 225, 3863, 6604 (in part), 17921 (G. I. No. 121) (Pl. II, E; fig. 8, a, b; fig. 9). Plants tall, stoutish, 2 to 3 meters (7 to 10 feet) high, bearing 9 to 13 leaves and 1 to 3 suckers; panicles lax, broadly oval, 2 to 3.5 dm. (8 to 14 inches) long, 1 to 2 dm. (4 to 8 inches) wide, heavy; spikelets 4 to 5.5 or 6 mm. long; seeds obovate oval, 3.5 to 5.5 mm. long by 3 to 4.5 mm. wide, bay, walnut brown, or cinnamon, bleaching to burnt sienna and buff; glumes shining black, about one-third shorter than the seeds.

A tall, late variety, maturing in 120 to 140 days. Named for Prof. N. E. Hansen, horticulturist of the South Dakota Experiment Station and Agricultural College and agricultural explorer for the United States Department of Agriculture, who sent the seed of S. P. I. No. 225, the earliest official introduction. Comparable to Brill Black-hull among the white-seeded varieties.

** *Panicle lax, large, coarse, 9 to 14 inches long, oval or obovate oval, naked at base; plants 7 to 8.5 feet tall, medium in maturity (105 to 120 days).*

Tientsin Brown. S. P. I. Nos. 17923 (G. I. No. 123), 24991 (Pl. II, F; fig. 9). Plants 2 to 2.5 meters (7 to 8.5 feet) tall, stoutish, bearing 10 to 12 leaves; panicles large, lax, much branched, oval, 2.2 to 3.5 dm. (9 to 14 inches) long; basal branches 1 to 1.7 dm. (4 to 7 inches) long, ascending to appressed, commonly naked for half their length; spikelets large, oval, 4 to 6 mm. long; glumes black, or occasionally claret, shining; seeds large, mostly oval, some obovate, 4 to 5.5 mm. long by 3.4 mm. wide, one-third exerted, clay to russet and bay.

A variety of medium height and maturity, ripening in 105 to 120 days. The large heads are not well filled at the base. Differs from Hansen Brown chiefly in being earlier.

*** *Panicle finer, sparse, narrowly oval to cylindrical, 8 to 12 inches long; plant 6 to 8 feet tall, medium-late maturity (115 to 120 days).*

Meyer Brown. S. P. I. Nos. 6411 (Agrost. No. 1454), 18625 (fig. 8, d). Plants 1.8 to 2.4 meters (6 to 8 feet) in height; panicles lax, medium to large, 2 to 3 dm. (8 to 12 inches) long, oval or narrowly oval; lower branches 7 to 12 cm. (2.5 to 5 inches) long; rachis two-thirds as long as to equaling the panicle; spikelets oval, 4.5 to 6 mm. long; glumes shining, mostly black, occasionally seal brown; seeds 3.5 to 5.5 mm. long, 3 to 4 mm. wide, oval or obovate, exerted one-fourth, russet to bay or chocolate. A variety of medium height and medium maturity, ripening in 115 to 120 days.

**** *Panicle small to medium, oval, semicompact, 8 to 10 inches long.*

△ *Plant 5 to 8 feet tall, medium early (100 to 110 days).*

Kali Brown. S. P. I. No. 19187 (G. I. No. 193) (Pl. II, G). Plants slender, 1.5 to 2.4 meters (5 to 8 feet) in height; panicles small, rather compact, 1.5 to 2.2 dm. (6 to 8 inches) in length, the lower branches 5 to 10 cm. (2 to 4 inches) long, and the rachis five-eighths to five-sixths as long as the panicle; spikelets 4.5 to 5.5 mm. long; glumes

3 to 4 mm. long, black, shining; seeds obovate oval, 4 to 5 mm. long by 3 to 4 mm. wide; walnut brown or burnt umber or paler. A low to medium variety, early to medium early in maturity, ripening in 100 to 110 days. Differs from Manchu Brown chiefly in greater height and later maturity. Name suggested by its reported use on alkali soils.

△△ *Plant 4.5 to 7 feet tall, extra early to early (85 to 100 days).*

Manchu Brown. S. P. I. Nos. 939, 18518 (G. I. No. 171), 18611 (G. I. No. 191), 18612 (G. I. No. 192), 20612 (G. I. No. 261), 20620 (G. I. No. 262), 20627 (G. I. No. 264), 24478 (G. I. No. 328), 24992-24994 (G. I. No. 171), 24995 (G. I. No. 261) (Pl. II, H; fig. 10; fig. 12).

Plants 1.4 to 2 meters (4.5 to 7 feet) in height, slender, bearing 7 to 9 leaves and usually no suckers or only one per plant; panicles oval or narrowly ovate, 2 to 2.7 dm. (8 to 10 or 11 inches) long; spikelets oval, acute, 4.5 to 5.5 or 6 mm. long; glumes black, shining, exposing one-third of the seed; seeds obovate oval to oval, 4 to 5.5 mm. long, 3 to 4 mm. wide, mostly dark brown, as burnt sienna, burnt umber, and chocolate where exposed, and buff to russet where included.

A low to medium variety of Manchurian origin, extra-early to early, maturing in 85 to 105 or 110 days, according to locality and season. The most important variety, agronomically, extending the use of these plants into the Northern States.

b. Seeds small, broadly obovate or sublenticular.

* *Panicle small, slender, semicompact, 8 to 11 inches long.*

Hankow Brown. S. P. I. No. 6604 in part (Kans. Exp. Sta. No. 595) (G. I. No. 326) (Pl. II, I). Plants 1.5 to 2.1 meters (5 to 7 feet) in height; stems stoutish, 2.5 to 3 cm. (1 to 1.2 inches) in butt diameter; leaves 9 to 12 in number; panicles slender, oblong, semicompact, 2 to 3 dm. (8 to 12 inches) long; lower branches 6 to 10 cm. (2.5 to 4 inches) long; butts poor to fair; rachis continuous; spikelets 4 to 5 mm. long; seeds 3 to 4 mm. long by 2.5 to 3 mm. wide, obovate or broadly obovate to sublenticular, walnut brown to chocolate, scarcely exserted; glumes black, shining.

A medium-low variety, medium early in maturity, ripening in 105 to 112 days.

B. Glumes buff to various shades of red.

1. *Glume I flat, glume II keeled, not gibbous or ridged.*

a. Inflorescence umbelliform, rachis shortened.

* *Panicle medium (9 to 11 inches); branches shorter.*

Chihli Brush. S. P. I. No. 18626. Plants 1.8 to 2.4 meters (6 to 8 feet) in height; panicles obovate or obconical, umbelliform, heavy, much branched, 2.2 to 2.7 dm. (9 to 11 inches) long; branches 1 to 1.7 dm. (4 to 7 inches) long; rachis about one-third as long as the panicle; spikelets 4.5 to 5.5 mm. long, obovate oval; glumes cinnamon red to brick red to black; seeds obovate, 4 to 5 mm. long by 3 to 4 mm. wide, cream buff to burnt sienna, exserted one-fourth to one-third. Time of maturing not recorded.

** *Panicle elongated (12 to 18 inches); branches equaling the panicle.*

Baird Brush. S. P. I. Nos. 6406, 18614, 20706 (?) (G. I. No. 265) (fig. 9, c). Plants 1.8 to 2.7 meters (6 to 9 feet) in height; panicles very lax, 3 to 4.5 dm. (12 to 18 inches) long, umbelliform or with the rachis more or less produced, branches equaling the panicle, spreading and drooping, or appressed and the whole panicle nodding; spikelets oval, 4.5 to 6 mm. long; glumes shining, clay to tawny, 4 to 5 mm. long, covering three-fourths or more of the seed; seeds obovate to oval, clay to russet, one-fourth exserted, 4 to 5.5 mm. long by 3 to 3.5 mm. wide.

A medium to tall variety, medium late (120 days) in maturity, of value only as a possible stock for broom-corn experiments.

b. Inflorescence paniculate; oval, ovate, or conical.

* *Panicle broadly oval, lax, heavy, 2.5 to 3.5 dm. (10 to 14 inches) long; rachis somewhat shortened, upper branches 1 to 1.2 dm. (4 to 5 inches) long, more than half as long as the lower; color effect, light brown.*

△ *Seeds large, broadly obovate or oval to sublenticular; glumes buff to cardinal and maroon.*

Valley Brown. S. P. I. Nos. 16792 (G. I. No. 152), 21078 (G. I. No. 273), 22911 (G. I. No. 309), 28057 (G. I. No. 423) (Pl. II, J; fig. 14, a, c). Plants 1.8 to 2.7 meters (6 to 9 feet) in height, stoutish, bearing 8 to 11 leaves, 7 to 9 cm. (2.7 to 3.5 inches) wide, and 6 to 6.7 dm. (2 to 2.2 feet) long; panicles large, broadly ovate or oval, heavy, 2.5 to 5 dm. (10 to 15 inches) long and half as wide, the lower branches 1 to 2 dm. (4 to 8 inches) long, the upper 1 to 1.2 dm. (4 to 5 inches) long; spikelets obovate, 4.2 to 5.7 mm. long; glumes mostly buff to clay, shading to cardinal, burnt sienna, and even maroon, seeds large, broadly obovate oval to sublenticular or subeppherical, less flattened than most varieties, 3.5 to 5 mm. long by 2.5 to 4 mm. wide, cream, or mostly buff or clay, to russet, chestnut, and burnt umber.

A variety of medium height and early to medium-early maturity, ripening in 95 to 105 days. G. I. No. 309, especially, is considered very promising as a variety for middle latitudes and elevations.

△△ *Seeds large, oval to obovate; glumes paler.*

Moose Brown. S. P. I. No. 27555 (G. I. No. 414). Plants 2 to 2.4 meters (6.5 to 8 feet) in height, stoutish, 1.3 to 2.5 cm. (0.5 to 1 inch) in butt diameter; leaves 11 to 13 in number, 6 to 7.5 cm. (2.2 to 3 inches) wide, 7 to 7.5 dm. (2.2 to 2.5 feet) long; panicles large, lax, subconical or mostly one-sided and forming a right-angled triangle in shape, 2.5 to 3.5 dm. (10 to 14 inches) long, lower branches 7 to 15 cm. (3 to 6 inches) long, upper branches 1 dm. (4 inches) long; rachis about three-fourths as long as the panicle; spikelets 4.5 to 5 mm. long; glumes coriaceous, 4.5 to 5 mm. long, clay to burnt sienna or, in 1910 and 1911, a shining cream, edged with pink to hazel; seeds oval or obovate, 4 to 4.7 mm. long by 3 to 3.5 mm. wide, in original sample clay to chestnut, nearly included, much paler in 1910 and 1911. A variety of medium height and of medium-late maturity, ripening in 114 and 120 days in the two seasons tested.

** *Panicle conical, lax, heavy, 2.5 to 3.5 dm. (10 to 14 inches) long; upper branches 5 to 7 cm. (2 to 2.8 inches) long; rachis nearly equaling the panicle.*

△ *Glumes, especially glume I, exceeding the seed, 5 to 6 mm. long.*

Ware Brown. S. P. I. No. 28027 (G. I. No. 421) (Pl. II, K). Plants 1.6 to 2 meters (5.5 to 6.5 feet) in height, slender to medium; leaves 10 to 11 in number, 7 to 8 cm. (2.7 to 3.2 inches) wide, 6 to 6.7 dm. (2 to 2.2 feet) long; panicles conical, lax, heavy (elliptic-oval in part of original plants), 2.5 to 3.5 dm. (10 to 14 inches) long, lower branches 1.2 to 1.7 dm. (5 to 7 inches) in length, upper branches 5 to 7 cm. (2 to 2.8 inches) long; rachis nearly equaling panicle; spikelets 4.5 to 5 mm. long; glumes raw sienna to Chinese orange and maroon or, in 1911, cream buff to cinnamon rufous, tinged with heliotrope; seeds obovate or oval, 4 to 4.5 mm. long by 3 to 3.8 mm. wide, clay to russet to burnt sienna, in 1910 clay tipped with hazel to brick red. A medium-low and early to medium-early variety, ripening in 92 days in 1910 and in 92 to 110 days in 1911.

△△ *Glumes equaling or shorter, especially glume II, than the seed, 4 to 5 mm. long.*

+ *Peduncles red.*

Redstem. S. P. I. No. 22011 (G. I. No. 327). Plants medium, 1.8 to 2.7 meters (6 to 9 feet) in height; slender to medium in diameter and usually without suckers; culms, especially the upper internodes, peduncle and rachis a beautiful madder brown or maroon; leaves 9 to 12 in number, 5 to 7 cm. (2 to 2.7 inches) wide, 6 to 6.7 dm. (2 to 2.2 feet) long; panicles sparse, light weight, lax, ovate or becoming one-sided by the bending of the peduncle, 2.2 to 3 dm. (9 to 12 inches) long, the lower branches 7 to 15 cm. (3 to 6 inches) long, spreading; rachis nearly equaling the panicle; spikelets large, oval, or suboval, 4.5 to 6 mm. long; glumes orange vermilion to maroon, occasionally buff; seeds oval or obovate oval, 4 to 5 mm. long by 3 to 3.7 mm. wide, cream buff to hazel to bay, one-fifth exserted. An early variety of medium height, ripening in 95 days, and strikingly characterized by the reddish brown stems. Of little value because of the light, sparse panicle.

++ *Peduncles straw color.*

○ *Lower panicle branches 1.2 to 1.6 dm. (5 to 6.5 inches) long.*

† *Branches stout, rigid; seeds acute.*

Parker Brown. S. P. I. No. 28058 (G. I. No. 424) (Pl. II, L). Plants 1.8 to 2.1 meters (6 to 7 feet) in height, 1.2 to 2 cm. (0.5 to 0.8 inch) in diameter at the butt; leaves 10 to 12 in number, 9 to 10 cm. (3.5 to 4 inches) wide, 6 to 6.7 dm. (2 to 2.2 feet) long; panicles exserted 7 to 15 cm. (3 to 6 inches), narrowly elliptical, 2.2 to 3 dm. (9 to 12 inches) long; branches stout, rigid, the lower 1 to 1.5 dm. (4 to 6 inches) in length; rachis three-fifths as long as the panicle; spikelets 4 to 5 mm. long; glumes vinaceous cinnamon to maroon to black in 1910, and clay to hazel to chestnut in 1911; seeds rhombic oval to obovate, acute, 3.5 to 5 mm. long by 3 to 4 mm. wide, buff to burnt sienna in the original and in 1911, in 1910 cream to raw sienna to hazel. A variety of medium height and early maturity, ripening in 92 and 96 days in the two seasons tested.

†† *Branches slender, flexible; seeds obtuse.*

= *Seeds elliptical or narrowly oval.*

Shasi Brown. S. P. I. No. 21678 (G. I. No. 278) (Pl. II, M). Plants 1.9 to 2.4 meters (6.5 to 8 feet) in height, culms 2 to 2.5 cm. (0.7 to 1 inch) in butt diameter; leaves 10 to 11 in number, 5 to 6.5 cm. (2 to 2.5 inches) wide by 6.7 to 7.5 dm. (2.2 to 2.5 feet) long; panicles broadly conic, or one-sided from the leaning of the culms. 2.7 to 3.5 dm. (11 to 14 inches) long, exserted 2.5 to 7.5 cm. (1 to 3 inches), branches slender, flexible, the lower 1 to 2 dm. (4 to 8 inches) long, the upper 6 to 7 cm. (2.5 to 3 inches) long; spikelets 4 to 5.3 mm. long; glumes 3.5 to 4 mm. long, clay and tawny to orange vermilion, ferruginous and crimson; seeds oval, broadly oval or obovate, 3.8 to 4.7 mm. long by 2.8 to 3.6 mm. wide, mostly russet or some burnt umber in original sample, cream buff to burnt sienna in 1911, about one-third exserted. A variety of medium stature and maturity, ripening in 110 days in the single test made.

== *Seeds broadly oval to sublenticular.*

Peesan Brown. S. P. I. Nos. 17922 (G. I. No. 122), 24990 (Pl. II, N). Plants 1.8 to 2.4 meters (6 to 8 feet) in height, bearing 9 to 11 leaves, 9 to 11 cm. (3.5 to 4.5 inches) wide, 6 to 6.7 dm. (2 to 2.2 feet) long; suckers 1 to 3 in number; panicles conical, 1.5 to 2.7 dm. (6 to 11 inches) long, mostly one-sided by the flexing of the peduncle; branches slender, the lower 1 to 1.5 dm. (4 to 6 inches) long; spikelets oval, 4 to 5.6 mm.

long; glumes covering three-fourths of the seed, clay to madder brown; seeds mostly oval, some broadly obovate, 3.5 to 5 mm. long by 3 to 4 mm. wide, russet to bay in original, some of the later generations cream buff to raw sienna to hazel.

The original was a considerable mixture from which has been isolated the low and medium-early strain, G. I. No. 122, 4.5 to 5.5 feet in height and maturing in 110 to 115 days.

○○ *Lower panicle branches 5 to 10 cm. (2 to 4 inches) long.*

Ichang Brown. S. P. I. No. 21676 (G. I. No. 276). Plants about 2 meters (7 feet) high, culms stout, 2.5 to 3 cm. (1 to 1.2 inches) in butt diameter; leaves 11 to 13 in number, 7 to 9 cm. (3 to 3.7 inches) in width, 7.5 to 8 dm. (2.5 to 2.7 feet) long; panicles conical, loose, 2.7 to 3.2 dm. (11 to 13 inches) long, exerted 2 to 7.5 cm. (1 to 3 inches), lower branches 0.5 to 1 dm. (2 to 4 inches) long, upper branches 3 to 5 cm. (1 to 2 inches) long; spikelets obovate oval, 4 to 4.8 mm. long; glumes clay and cardinal to madder brown and claret brown; seeds broadly oval to obovate oval, 3.5 to 4.5 mm. long by 2.8 to 3.8 mm. wide, cream to chestnut to burnt sienna. A variety of medium height and medium maturity, ripening in 110 days in the single test made. Distinguished from Peesan Brown chiefly by the longer heads and darker glumes. Quite probably it is equivalent to one of the forms discarded from S. P. I. No. 17922, from which Peesan Brown was selected.

*** *Panicles small, oval, compact, 3 to 6 inches long; seeds small, broadly obovate to sublenticular.*

Chusan Brown. S. P. I. Nos. 23230 (G. I. No. 323), 23231 (G. I. No. 324) (Pl. II, O). Plants low to medium, 1.2 to 2 meters (4 to 7 feet) in height, bearing 8 to 10 leaves, 8 to 10 cm. (3.2 to 4 inches) wide, 6.7 to 7.5 dm. (2.2 to 2.5 feet) in length; panicles small, 1.2 to 2 dm. (5 to 8 inches) long, narrowly oval, lower branches 2 to 3.5 inches long, seeded to their base, rachis equaling the panicle; spikelets broadly obovate, 3.5 to 4.2 mm. long; glumes short, brick red to maroon or chestnut to bay, shining; seeds small, broadly obovate or sublenticular, 3 to 4 mm. long by 2.5 to 3.5 mm. wide, bay to burnt umber to chocolate. A low to medium variety with small, compact panicles and small, nearly round seeds; medium to medium late, ripening in 110 to 129 days. Of little promise.

2. *Glumes gibbous at the base, transversely ridged above the middle, with depressed tip.*

a. *Spikelets small, broadly obovate or sublenticular; panicle large, lax; plant medium height.*

Tokyo Brown. Agrost. Nos. 1576, 1586; S. P. I. Nos. 4905 (G. I. No. 277), 21677 (Pl. II, P). Plants 1.5 to 2.1 meters (5 to 7 feet), slender to medium, suckering freely; leaves 11 to 12 in number, 8 to 10 cm. (3.5 to 4 inches) wide, 7.5 to 8.2 dm. (2.5 to 2.7 feet) in length; panicles lax, ovate-conical, large, 2 to 3.5 dm. (8 to 14 inches) long, heavy, apex often nodding, branches 1 to 1.5 dm. (4 to 6 inches) long, ascending or spreading and nodding at the apex; spikelets mostly 3 to 4 mm. long, almost spherical; glumes coriaceous, short, transversely shouldered or ridged, the apex depressed and closely appressed to the seed, clay to brick red or vinaceous cinnamon to maroon in the first two and last forms, from mostly cream buff through heliotrope to burnt sienna and claret brown in the third; seeds 3 to 4 mm. by 2.5 to 3.8 mm. in size and mostly chestnut to burnt sienna or darker, very broadly obovate to nearly lenticular in the first two and last, still smaller, rounder, and clay or dark clay in the third. A low to medium variety of medium maturity, ripening in about 110 days.

b. *Spikelets medium to large, oval; panicle small to medium, compact.*

* *Plant medium; spikelets medium; panicle small, slender.*

Choonchun. S. P. I. No. 27554 (G. I. No. 413) (Pl. II, Q). Plants slender, 1.3 to 2 meters (4.5 to 6.5 feet) tall, medium stout, bearing 10 to 12 leaves, 7.5 to 9 cm. (3 to 3.5 inches) wide, 6 to 6.7 dm. (2 to 2.2 feet) long; panicle small, cylindric oval, compact, 1.5 to 2 dm. (6 to 8 inches) long, with continuous rachis, lower branches 7.5 to 10 cm. (3 to 4 inches) long; spikelets ovate or broadly oval, 4.5 to 5 mm. long; glumes 3 to 3.5 mm. long, clay to orange vermilion to deep crimson, edged with dark brown, covering two-thirds of the seed; seeds broadly oval or obovate oval, 4 to 5 mm. long by 3 to 3.8 mm. wide, clay to russet to burnt umber, or cream buff to brick red in 1910. A low variety of medium-early maturity, ripening in 103 and 98 days in the two seasons grown. Not promising.

** *Plant very dwarf; panicle heavy, compact, oval; spikelets large.*

Shantung Dwarf. S. P. I. No. 22010 (G. I. No. 293) (Pl. II, R; fig. 13; fig. 14b). Plants stout, very dwarf, 0.6 to 0.9 meter (2 to 3 feet) tall, averaging 2.5 cm. (1 inch) in diameter at the butt; leaves 8 to 11 in number, 1 to 1.2 dm. (4 to 4.8 inches) wide, 5.2 to 6 dm. (1.7 to 2 feet) in length; panicles stout, heavy (averaging 3 ounces each) oval, compact, 2 to 2.5 dm. (8 to 10 inches) long; spikelets broadly oval, occasionally obovate or even ovate, 4 to 5.5 mm. long; glumes 3.5 to 4 mm. long, gibbous at the base, transversely ridged above the center, the apex depressed and closely appressed to the seed, buff to burnt sienna or in later years cream to clay and madder brown; seeds broadly oval or obovate, 4 to 5 mm. long by 3 to 4 mm. wide, one-third exerted, russet to burnt umber, or, in later years, raw sienna to burnt sienna. A very dwarf, medium-early variety, 2 to 3 feet in height, and maturing in 100 to 110 days.

AGRICULTURAL VALUE.

GENERAL CHARACTERS.

The kaoliangs have been too recently introduced and have required too much rigid selection to allow final judgment as to their place among the grain varieties. They are of almost no value as forage, owing to the dry stems and the few and small leaves. They are not likely to displace any of the leading groups of grain sorghums, such as the milos, durras, and kafirs, now grown in this country. At the same time, on account of their earliness, and perhaps greater hardiness also, they have apparently a distinct place of their own to fill in the more northern and more elevated parts of the dry-farmed areas.

As previously stated, the kaoliang varieties, when introduced from the Orient, are frequently mixtures of varieties and almost certainly mixtures of races or strains also. In order to obtain uniformity and value as grain producers it has been necessary to isolate the highest producing strains by the head-to-row method. Table V shows the number of varieties or separate introductions under test since 1906 and also the number of selections made each year and the number of these selections which were planted the succeeding season.

TABLE V.—Record of kaoliang varieties or introductions under test at the experiment farm of the Office of Grain Investigations at Amarillo, Tex., since 1906, and the number of selections made therefrom annually.

Year.	Planted.				Selections made.		
	Number of lots—			Number of select heads.	Number of lots—		Number of heads selected.
	From original seed.	From select heads.	Total.		Dis-carded.	Selected.	
1906	6	0	6	0	1	5	43
1907	11	5	16	43	3	13	391
1908	6	11	17	243	2	15	479
1909	5	11	16	150	1	15	610
1910	7	15	22	164	0	22	440
1911	3	22	25	186	0	25	255

The group contains a large assortment of varieties, some early, some late; some dwarf, some tall; some compact, some lax in panicle; some with large seeds and some with small. They all unite in having small to medium stalks, containing dry pith and bearing comparatively few (6 to 11) leaves. Since the crop has so little forage value the tall varieties are not desirable. The late varieties are usually tall also, but even if they were not they would have no advantage, except possible lower water requirements, over the equally late kafirs in regions where late sorts can be matured. The medium-maturing varieties of medium or low stature must compete with the well-known and popular milo varieties as grain producers and are of even less value for forage. Their chief advantage is their always erect head. It follows, then, that there is real need at present for only the very early strains which can be matured farther north and at higher elevations than milos. Such varieties have been obtained, improved by some years of selection, and are now giving good results in South Dakota and other points farther north, as well as on the elevated plains of New Mexico and Colorado.

Owing to their low water requirements and tendency to produce but one stalk from a seed it has been possible to mature good crops of kaoliangs in dry years where milo largely failed. If moisture is comparatively abundant in the early part of the growing period, milo is likely to put forth so many suckers as to seriously handicap the crop when dry weather sets in. The kaoliangs are less prolific in this regard and can therefore endure drought more successfully. This fact gives value to the kaoliangs in the drier parts of the central Plains area. The kaoliangs seem also to be slightly less susceptible to chinch-bug injury than the milos, though more so than the kafirs.

PROMISING VARIETIES.

Out of the considerable number of actual varieties tested and classified, only a few give promise of definite value for definite areas.

All of these are early or medium in maturity. The later varieties are not only tall, which is objectionable, but can scarcely compete with the popular milo and kafir varieties.

From the standpoint of the characters and quality of the seed there is probably but little to choose among the varieties. The members of the white-seeded section are perhaps preferable because the seed coats contain no tannin. But because of this very fact they are the more eagerly sought by birds. Small fields are often severely damaged by the inroads of English sparrows, blackbirds, and other species. To date it is true also that the earliest forms in the white-seeded section are appreciably later than the earliest of the brown-seeded sorts. However, earlier white strains are being evolved and the present superiority of the brown varieties in this respect is likely to be diminished gradually.

As to other characters than color of the seed there is little choice among the different varieties except in earliness. For use at high elevations and in northerly latitudes the very earliest strains must be chosen. Under more favorable conditions any of the best producing varieties may be safely used.

Tests in the Texas Panhandle.—Table VI shows the performance of some of the best sorts at the Amarillo experiment farm of the Office of Grain Investigations during the past four years. Some of these varieties were under experiment at that point previous to 1908, but pure strains were not available for plat tests before that year. In 1908 most of the tests were in hundredth-acre or fiftieth-acre plats. In 1909, 1910, and 1911 all the standard sorts were tested in one or more tenth-acre plats. The yields recorded for 1910 and 1911 are often the average of several tenth-acre plats, in one case as many as seven being averaged.

TABLE VI.—*Length of growing period, height, and yield per acre of several varieties of kaoliang at the experiment farm, Amarillo, Tex.*

G. I. No.	Variety.	Growing period.	Height.	Yields per acre.				
				1908	1909	1910	1911	Average.
		<i>Days.</i>	<i>Feet.</i>	<i>Bush.</i>	<i>Bush.</i>	<i>Bush.</i>	<i>Bush.</i>	<i>Bush.</i>
120.....	Brill Blackhull.....	120-135	7-12			1.84	19.31	10.57
412.....	Korean Blackhull.....	100-105	6-8			*10.34	15.96	13.15
310.....	Barchet Blackhull.....	100-110	4.5-5.5	*43.10	19.44	8.58	130.75	22.97
190.....	Mukden White.....	105-115	5-8		12.80	12.19	25.07	16.66
272.....	do.....	105-115	6-8		*18.10	15.74	*7.24	15.56
123.....	Tientsin Brown.....	105-120	7-8	*31.31	9.89	6.52	27.50	18.90
193.....	Kali Brown.....	100-110	5-8	*26.29	12.82	9.95	25.05	18.53
171.....	Manchu Brown.....	90-100	4.5-6	133.38	114.19	114.32	29.29	22.77
261.....	do.....	85-95	4.5-6.5	20.85	11.43	6.16	116.99	13.86
328.....	do.....	85-95	4.5-6			7.45	121.36	14.40
309.....	Valley Brown.....	95-105	6	*37.41	16.03	115.01	30.98	24.86
122.....	Peasan Brown.....	110-115	5-6	133.86	114.76	11.69	26.55	21.79
324.....	Chusan Brown.....	110-120	4-6			* 6.47	21.30	13.89
293.....	Shantung Dwarf.....	105-110	2.5-3	*33.62	3.49	6.64	27.62	17.84

* Less than a twentieth-acre plat.

† Average of two or more tenth-acre plats.

The yields for the first three years are in decreasing series, due to severe climatic conditions. The rainfall for the past five years at the Amarillo farm is shown in the following table:

TABLE VII.—*Precipitation in inches per month at Amarillo, Tex., for five years from 1907 to 1911.*

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1907.....	1.11	0.24	0.02	1.25	0.99	1.97	1.49	6.20	0.91	1.79	0.66	1.46	18.09
1908.....	.26	.72	T.	1.90	3.55	1.73	5.40	2.75	1.83	.40	.51	.00	19.05
1909.....	.07	.28	1.28	.50	1.08	4.72	3.63	.87	2.19	1.18	3.25	.54	19.59
1910.....	.05	.17	.34	.53	2.61	1.15	2.94	2.44	.05	.13	.19	T.	10.60
1911.....	.13	2.88	.50	2.76	5.88	.20	3.85	2.97	.83	.84	.94	.95	22.73

The rainfall of four of these five years was below the average for the 15 years preceding 1907, which was 22.5 inches. The yields recorded for 1908 are good, those for 1909 average less than half as large, while those of 1910 are still lower. In 1911 the yields rise again. The discrepancy in the yields of 1908 and 1909 does not arise from a difference in annual precipitation, but from the difference in seasonal distribution and in part from the cumulative effect. In 1908 the rainfall was abundant during the six months, April to September, which determine the success of these summer crops, being highest in May, the month of planting, and in July, the month of greatest growth. In 1909, on the other hand, the season was dry until June, and August, the month of heading or ripening, was also very dry. The yields of the year 1910 are readily explained by the very deficient rainfall following a fairly dry season in 1909. The average yields for the four years are very good, considering the seasonal conditions. That four of these kaoliang varieties should have been able to produce average yields of more than 20 bushels an acre under the conditions obtaining in these four years is very gratifying. Five other varieties or strains made average yields ranging from 13.8 bushels to 18.8 bushels in the same period. The average yield for these nine strains is 19.7 bushels for the four-year period.

In comparison with the above records, nine varieties of corn made an average yield in 1908 of only 10.06 bushels per acre. In 1909 a larger number of varieties ranged from nothing to about 7 bushels in yield, while in 1910 no yields whatever were obtained. In 1911 the average yield of 26 varieties was 4.27 bushels per acre. The best variety of corn, a red dent of local origin, averaged only 10.02 bushels for this four-year period. The three-year average of all corn varieties was certainly much below 5 bushels.

Tests in the central Plains area.—The performance of these kaoliangs at Amarillo may be taken as a fair sample of what may be expected of them in the grain-sorghum belt or the southern half of

the Great Plains area, due allowance being made for differences in elevation, rainfall, etc. Similar results have been obtained at the experiment farm, Dalhart, Tex., in cooperation with the Office of Dry-Land Agriculture. Tests by large numbers of cooperating farmers in Oklahoma, Kansas, New Mexico, and Colorado have given results as good as or better than those cited above.

The choice of varieties from among the best recorded in Table VI will be governed largely by the need for earliness. For Texas, Oklahoma, and western Kansas such varieties as Barchet Blackhull and Manchu Brown, Kali Brown, Valley Brown, and Peesan Brown are well adapted. For the higher elevations in New Mexico and Colorado as well as for western Nebraska and South Dakota only the earliest strains of Manchu Brown are certain to mature.

Manchu Brown, as noted in the discussion of introductions, is a very early variety of low stature originating in Manchuria. It was obtained from several widely separated localities of that division and is probably the dominant, if not, indeed, the only variety grown in the higher latitudes of Manchuria and the adjacent provinces of Siberia. It is possible that its northern origin has given it the power of germinating at lower mean daily temperatures than varieties originating farther south. At any rate, better stands are usually obtained from strains of this variety in the Dakotas and Montana than from any other kaoliangs or any other group of grain sorghums.

Tests in South Dakota.—Three strains of Manchu Brown have been successfully grown in South Dakota. These are G. I. Nos. 171, 261, and 328. The exact origin of the first two is not known, but the last comes from the Harbin district, in the province of Kirin, at 46° north latitude, or higher. The tests were made at the Highmore substation in cooperation with the department of agronomy of the South Dakota Agricultural Experiment Station, and the earlier results have already been published by Willis and Champlin,¹ of that station.

The latitude of Highmore is 44.5° north, the elevation 1,890 feet, the average annual rainfall 17.4 inches, and the soil a glacial clay loam.

Table VIII contains the data obtained in these tests during 1909 and 1910, adapted from the table on page 54 of the bulletin cited, with the data for 1911 added. The average yield of the three strains for the two years is seen to be 16.5 bushels, and for the three years 13.7 bushels per acre. These kaoliangs were tested each year in tenth-

¹ Willis, Clifford, and Champlin, Manley. Progress of Grain Investigations. Bulletin 124, South Dakota Agricultural Experiment Station, November, 1910, p. 56.

acre plats, drilled in rows 3.5 feet apart with a row space of about 6 inches for each plant.

The year 1910 was deficient in rainfall at Highmore, and 1911 will long be remembered for the drought prevailing during the growing season of these crops.

TABLE VIII.—*Results with Brown Manchu and Barchet Blackhull kaoliangs at Highmore (S. Dak.) substation, 1909 to 1911.*

Year.	Data of test.	Varieties.				
		Manchu Brown.				Barchet Blackhull, G. I. No. 310.
		G. I. No. 171-8, Highmore No. 92.	G. I. No. 261-4, Highmore No. 91.	G. I. No. 328, Highmore No. 90.	Average yield of three strains.	
1909....	Planted.....	May 19	May 19	May 19	.....	May 19
	Headed.....	Aug. 7	Aug. 4	Aug. 1	.....	Aug. 14
	Ripened.....	Sept. 12	Sept. 10	Sept. 10	.....	Oct. 12
	Days to mature.....	117	114	114	.....	146
	Yield..... bushels..	14.8	14.0	14.8	14.5	2.4
1910....	Planted.....	May 18	May 18	May 18	.....	.....
	Headed.....	July 30	Aug. 2	Aug. 2	.....	.....
	Ripened.....	Sept. 12	Sept. 9	Sept. 7	.....	.....
	Days to mature.....	116	114	110	.....	.....
	Yield..... bushels..	19.2	20.0	16.4	18.5	.....
	Average yield for 2 years.....do....	17.0	17.0	15.6	16.5	.....
1911....	Planted.....	May 19	May 19	May 19	.....	.....
	Headed.....	Aug. 4	July 31	Aug. 1	.....	.....
	Ripened.....	Sept. 5	Sept. 1	Sept. 1	.....	.....
	Days to mature.....	109	105	105	.....	.....
	Yield..... bushels..	10.3	6.0	8.2	8.2	.....
	Average yield for 3 years.....do....	14.8	13.3	13.1	13.7	.....

Fifteen varieties of corn grown in 1909 gave an average yield of 18.2 bushels per acre. The varietal test, continued for three years, was then abandoned and only the two best varieties were grown in 1910. Eighteen plats of Minnesota No. 13 averaged 7.5 bushels, and fourteen plats of Brown County Yellow averaged 9.7 bushels per acre. In 1911 a single ear-row plat of each was grown, yielding 15.3 and 6.8 bushels per acre, respectively.

At the Bellefourche experiment farm, Newell, S. Dak., experiments are conducted in cooperation with the Office of Western Irrigation Agriculture. The latitude is 44.7° north, the elevation 2,900 feet, the average annual precipitation 14 or 15 inches, and the soil a heavy clay or gumbo. The effects of the increased altitude and latitude, heavier soil, and lower precipitation are indicated by the results given in Table IX. The tests were conducted by Mr. Cecil Salmon, in charge of grain investigations at that station.

In 1909 the strains were tested in hundredth-acre head rows, except No. 171, which was in a tenth-acre plat. In 1910 all strains

were tested in two-hundredth-acre head rows. While the yields so far obtained are not high, they give promise that further selection will result in profitable strains. The spring and summer of 1911 were exceedingly dry. The seed of none of the spring-sown small grains germinated and therefore no grain sorghums were planted.

TABLE IX.—*Results with Manchu Brown kaoliang at Bellefourche experiment farm, Newell, S. Dak., in 1909 and 1910.*

Year.	Data of test.	G. I. No. 171.	G. I. No. 261-3-1.	G. I. No. 261-3-2.	G. I. No. 261-3-3.	G. I. No. 261-3-4.	G. I. No. 261-3-5.	G. I. No. 261-4.	G. I. No. 323.	Aver- age.
1909..	(Planted.....)	June 14	June 5	June 5	June 5	June 5	June 5	June 5	June 14	.....
	(Headed.....)	Aug. 25	Aug. 23	Aug. 23	Aug. 24	Aug. 24	Aug. 23	Aug. 24	Aug. 25	.....
	(Ripened.....)	Sept. 20	Sept. 18	Sept. 18	Sept. 18	Sept. 18	Sept. 18	Sept. 18	Sept. 20	.....
	(Days to mature.....)	98	105	105	105	105	105	105	98	.....
	(Yield.....bushels..)	12.7	19.0	5.7	8.5	6.6	13.3	12.3	9.5	10.95
1910..	(Planted.....)	May 23	.....	.....	.....	.....	May 23	May 23	May 23	.....
	(Headed.....)	Aug. 12	.....	.....	.....	.....	Aug. 12	Aug. 15	Aug. 9	.....
	(Ripened.....)	Sept. 30	.....	.....	.....	.....	Sept. 30	Sept. 30	Sept. 30	.....
	(Days to mature.....)	130	.....	.....	.....	.....	130	130	130	.....
	(Yield.....bushels..)	7.66	.....	.....	.....	.....	13.22	12.45	8.62	11.40
	Average yield for 2 years.....bushels..	10.18	.....	.....	.....	.....	13.26	12.37	9.06	11.22

° Not fully mature.

† Four selections only.

The three strains of Manchu Brown matured from 0.45 of a bushel to 1.2 bushels at the substation at Dickinson, N. Dak., in 1909, but were killed by frost without ripening in 1908 and 1910. In 1911 two strains ripened a little seed at Dickinson and also at Williston, in the northern part of the State. In Montana they have not yet been able to ripen successfully, though the results in 1911 with early strains from South Dakota have been quite promising. In parts of Idaho some good yields have been obtained by a few cooperating farmers. These strains give promise of value at the substation at Moro, Oreg., but it is too early to speak definitely as to their value there.

CULTURE OF KAOLIANGS.

The varieties of the kaoliang group are handled in all respects as are the other and better known groups of grain sorghums, viz., milo, durra, kafir, etc. The seeds of the kaoliangs are similar to those of the kafir varieties in size and shape, and the same adjustment of the planter will cause the same rate of seeding of both. They should be drilled in rows approximately 3½ feet apart, with a row space for each plant varying from 6 to 12 inches, according to climatic conditions. It is probable that under the conditions obtaining in the southern part of the Plains area in average or favorable seasons, a stand of one stalk to each 5 or 6 inches will give the best results. At higher elevations, or farther north, or in dry seasons thinner stands will be desirable. In regions subject to the frequent recurrence of

dry seasons, and this probably includes all the so-called semiarid areas of the West, it is probable that a thin planting of a portion of the area devoted to grain sorghums each year will serve in a measure as insurance against a total loss of the crop. This practice has been followed in past years by a number of farmers with very good results. Like other grain sorghums, they should not be sown until the danger of spring frosts is well past.

SUMMARY.

The kaoliangs are a distinct group of grain-producing sorghums only recently introduced from eastern Asia.

They are found throughout the eastern half of the Chinese Empire, except in the low southeastern provinces, and extend northward and eastward through Manchuria and Chosen (Korea) to Japan. They are most abundantly grown in the northern part of this area, especially in Chihli and Manchuria.

No other sorghums are found in the region named except a variety of sorgo cultivated locally on and about Tsungming Island in the mouth of the Yangtze River. They are probably the descendants of varieties imported into China from India many centuries ago.

In the Orient the seed is used both for human and animal food and in the manufacture of liquor. The stalks are used for both fodder and fuel. In addition, the stems and leaves are used as material for thatching, fences, hedges, light bridges, and other building. They are also used in certain native manufactures, such as baskets, matings, window shades, etc. The brush of some varieties is used for native brooms.

Varieties of kaoliang were introduced into this country as early as about 1866, and again at subsequent times, but were discarded after brief cultivation for sugar production. Since 1898, 49 direct and 3 indirect introductions from eastern Asia have been made, representing more than half as many distinct varieties.

Most of these introductions have been tested by the writer through a series of years and at a number of stations, from the agricultural and varietal standpoints. Since 1906, all introductions have been tested for grain production. Those giving any promise of value have been subjected to head-to-row breeding for pure strains.

Descriptions of the plant and seed characters of all the introductions and a description of the group as a whole are presented in this paper.

Twenty-seven distinct varieties of kaoliang are named and described for the first time, with complete keys for their separation.

The kaoliangs are good grain producers, though of little value for forage on account of their scanty foliage. They are not likely to

displace any of the present groups of grain sorghums, such as the milos, durras, and kafirs, but on account of their earliness apparently have a distinct place of their own to fill in the more northern and more elevated parts of the dry-farmed areas.

The earliest variety, Manchu Brown, matures in 85 to 95 days in the southern Plains area, and in 100 to 110 days as far north as South Dakota. A number of high-yielding varieties mature in 110 days or less.

Of nine strains thoroughly tested at the Amarillo experiment farm from 1908 to 1911, inclusive, four produced average yields of more than 20 bushels per acre and the other five produced from 13.8 to 18.8 bushels per acre. The average yield for the nine strains was 19.7 bushels for the four-year period. The annual rainfall of the first three years was below normal and the seasonal rainfall was deficient in the middle two. Average yields of corn varieties under the same conditions were less than 5 bushels.

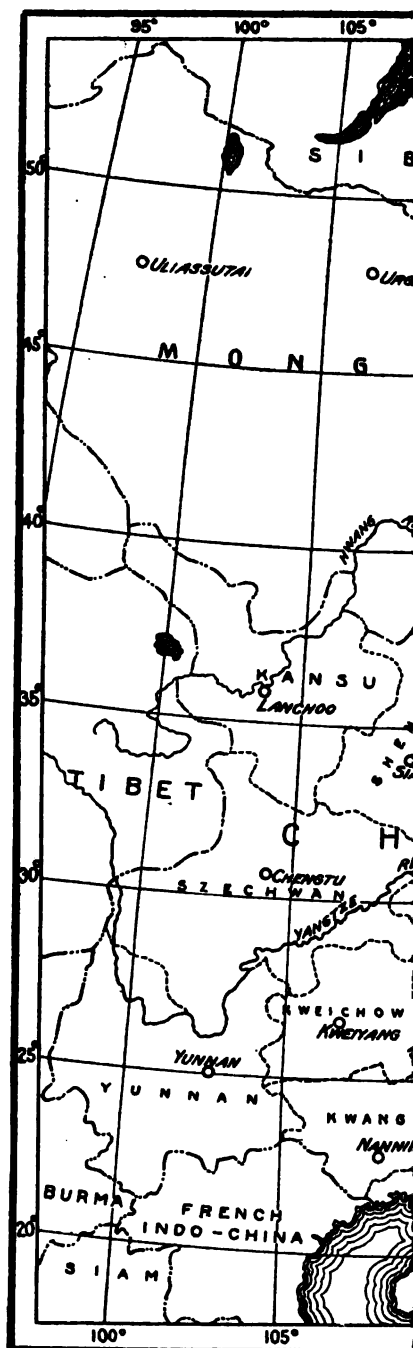
The strains of the extra-early Manchu Brown have been under test at various points in the Northwest during 1909, 1910, and 1911. At the substation at Highmore, S. Dak., they have produced an average yield of 13.7 bushels in the three-year period. At the Belle-fourche experiment farm, Newell, S. Dak., four strains gave a two-year average of 11.2 bushels per acre.

Promising results are being obtained at other points at high elevations or in high latitudes.

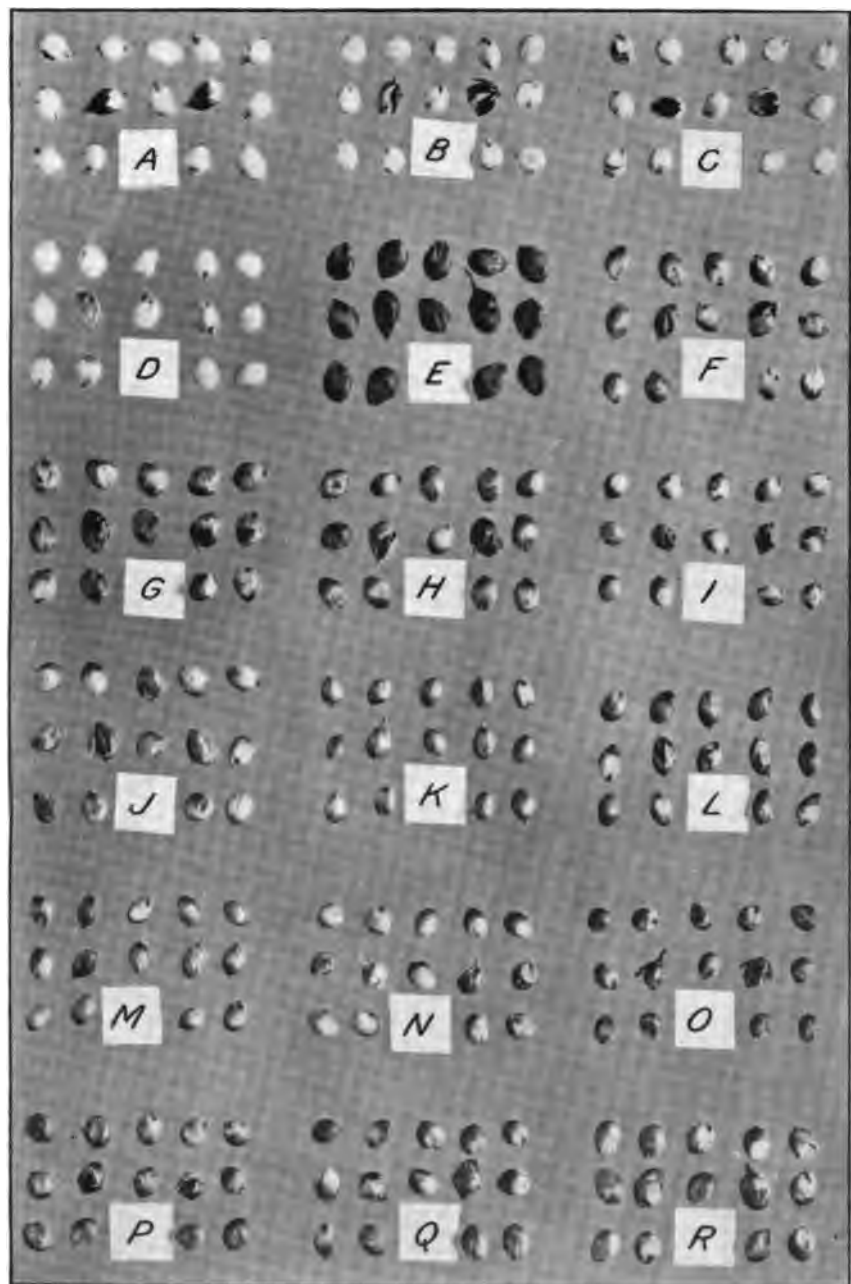
DESCRIPTION OF PLATES.

PLATE I. Map of eastern Asia, showing the provinces and larger cities of China, Manchuria, and Chosen (Korea).

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MAP OF EASTERN ASIA, SHOWING 1



SPIKELETS AND SEEDS OF KAOLIANG VARIETIES.



A WELL-KEPT PERSIAN WALNUT ORCHARD IN CALIFORNIA, ILLUSTRATING THE THOROUGH TILLAGE THAT MAY BE READILY MAINTAINED AMONG LOW-HEADED TREES.

Issued February 27, 1913.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 254.

B. T. GALLOWAY, *Chief of Bureau.*

THE PERSIAN WALNUT INDUSTRY OF THE UNITED STATES.

BY

E. R. LAKE,

Assistant Pomologist, Pomological Collections.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1913.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., July 1, 1912.

SIR: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 254 of the series of this Bureau the accompanying paper, entitled "The Persian Walnut Industry of the United States," by Mr. E. R. Lake, Assistant Pomologist, Pomological Collections, Bureau of Plant Industry.

The consumption and price of walnuts in the United States have greatly increased during the past decade, while the output of the home-grown product has been practically at a standstill, though rather extensive plantings have been made during the past ten years. The purpose of this paper is to explain in terms of actual orchard conditions why this apparent anomaly exists, and to present the best information obtainable as to the methods of making it possible to extend the area of successful cultivation of this nut. It aims further to answer the many questions now being propounded by a public that has been stimulated by alluring promises of marvelous incomes from orchard plantings of this tree.

Secondary aims of the author have been to describe the varieties of *Juglans regia* in such a manner as to make it possible for a layman to identify the known varieties and at the same time to lay the foundation for a systematic classification of this nut, to the end that a better knowledge of types and varieties will enable the planter to avoid many of the costly errors of the past.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

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THE PERSIAN WALNUT INDUSTRY OF THE UNITED STATES.¹

INTRODUCTION.

The Persian walnut, more generally spoken of as the English walnut, came into cultivation in western Europe by way of Greece. The early Greek names "Persicon" and "Basilicon," applied to this nut, imply that it was either "brought from Persia by the monarchs of Greece or sent thither by the kings of Persia." Later the Greeks called it "Caryon, on account of the heaviness of the head which its strong odor caused."

The tree was really first brought into cultivation in Italy with the dawn of the Christian Era. Prior to this time the nuts were an article of commerce coming to Rome and other western marts under a multiplicity of names from Greece and the interior of Asia Minor. Particularly did the names used by early authors, like *Grenoble* or *Sorrento* of to-day, which designate localities or even shipping points, indicate the region known as *Pontus* in Asia Minor as the source of this nut.

As verifying the view that the walnut was not cultivated in Europe prior to the birth of Christ, Hehn in his book entitled "*The Wanderings of Plants and Animals*" says:

In any case the want of settled names for these nuts proves that there was no general cultivation of these trees (almond, chestnut, and walnut) in Italy at the time of Cato, 234-149 B. C., though the walnut is mentioned several times by Varro, 116-27 B. C., and once by Cicero, 106-43 B. C., who relates that the daughters of Dionysius singed that tyrant's beard off with red-hot nutshells.

That the walnut was cultivated in other regions prior to the time the Romans introduced it into Europe is the opinion of De Candolle, who states that the Arabs knew it as *Jouz* or *Jown* at an earlier date.

¹ The writer desires to express sincere thanks to all those who, by contributions of data, specimens, or other material, have rendered valuable aid in the preparation of this bulletin. Especially to the following is he indebted for numerous favors: Prof. C. W. Beers, P. J. Berckmans Co., Leonard Coates, Dr. W. W. Fitzgerald, C. B. Franklin, Ferd Groner, L. C. Hall, Ely I. Hutchinson, F. A. Leib, M. McDonald, Dr. Robert T. Morris, J. B. Neff, George C. Payne, Pomeroy Bros., E. M. Price, Thomas Prince, J. G. Rush, C. C. Teague, Tribble Bros., the Vrooman Estate, E. G. Ware, and R. Wiltz.

The same author asserts that both the Bohemian name Oresak and the Biscayan name Encauria indicate that this tree was cultivated before the days of the Roman emperors. The Greek word "eros," which is found only once in the Bible, is held to be the term used to designate the walnut at that remote date.

It was during the imperial days of Rome, when it was commonly known as Jove's nut, Jupiter's acorn, or the nut of the gods, and used in the ceremonials associated with weddings, that the walnut was first distinguished by the name Juglandes. As an instance of the confusion that existed as to its name prior to this date, and which would appear to imply that only the crudest form of cultivation, if any at all, was accorded the walnut at that period, we find that "the popular name Jupiter's acorn, *Dios balanos*, which in Greek meant chestnut, has in the corresponding Latin form *Juglans* (Jovi-glans) the meaning of walnut."

The term "walnut" is a corruption of "Gall nut," the name under which the product of the trees of Gaul, the ancient name of France and adjacent territory, was marketed. It was probably first used by the Germans to designate the product as "the foreign nut."

The chief credit for bringing this tree under cultivation appears to belong to Vitellius, a Roman emperor, A. D. 39. Once established upon the soil of Italy it made rapid progress into the adjacent parts of Europe, being disseminated throughout the various territories covered by the Romans in their several northern and western invasions and remaining to bless the land as one of the beneficent incidents of devastating war after the conqueror had been conquered.

Though this tree, which is now known to science as *Juglans regia* and the product of which has been known successively or collectively to the trade as Persian, royal, Madeira, French, English, California, and even Oregon walnuts, was probably introduced into cultivation from Persia, it has been found growing in a state of nature in widely separated sections of the mountains of southwestern Asia, including northern India, southern China, Asia Minor, Afghanistan, the Caucasus, and in portions of southeastern Europe adjacent to Asia. Evidences of an even wider distribution of this tree in geologic ages is afforded by the fossils of the Tertiary period, which according to M. de Saporta show that it formerly existed in Provence and elsewhere in the southeastern portion of France. Other species of *Juglans* are catalogued from Jamaica, Spain, North and South America, Cuba, Japan, and Australia. At present it may be said that *Juglans*, through its various species, encircles the globe in the following manner: Eastern shore of Asia, *Juglans sieboldiana* and *J. cordiformis*, the Japan walnuts; western Asia and eastern Europe, *J. regia*, the royal walnut; eastern America, *J. nigra* and *J. cinerea*, the black walnut and the white walnut or butternut; western

America, *J. californica*, the California black walnut. There are two quite well-defined forms of *J. californica*. The northern form is a large tree, while the southern form usually assumes the habit of a large shrub. In the following pages reference is made to the northern form only. These species, together with the northern Chinese walnut (*J. mandshurica*), the Cuban walnut (*J. insularis*), the rock walnut of Texas (*J. rupestris*), three Mexican species, and those of South America afford evidence of adaptability to a wide range of environment.

DESCRIPTION OF THE PERSIAN WALNUT TREE.

The Persian walnut tree under favorable soil and climatic conditions is of large growth and long life. The following statements taken from the Gardeners' Chronicle, London, England, are cited as instances of the great growth and age to which this tree may attain:

The famous old Bechemwell tree in England had the following recorded dimensions: Height, 90 feet; spread, 120 feet; height of trunk, 10 feet; diameter of trunk, nearly 10 feet; yield of nuts in one season, 54,000.

The colossal tree that grew in the Department of Lot in France lived to be at least 300 years old, with a spread of 125 feet, a trunk 20 feet high and 14 feet in diameter. Its crop record was 15 bags a year on the average.

The giant walnut that stood in Baldar Valley, near Balaklava, in the Crimea, reached the age of 1,000 years, and for a long time yielded annually 80,000 to 100,000 nuts, the joint property of five Tartar families, who shared its product equally.

In California, trees reputed to be approximately 140 years old, and with trunks 4 feet or more in diameter, are to be seen in the oldest missions. In some of the larger commercial orchards, from 35 to 40 years old, are to be found many trees with trunks 2 feet in diameter and a spread of 80 feet.

One of the successful growers of Carpinteria, Cal., Mr. C. B. Franklin, has said that he can see no reason why a walnut orchard in that locality should not continue to bear profitable crops until the trees are 150 to 200 years old, provided they are given good care and planted at least 45 feet apart on deep, mellow, rich soil.

In a more conservative view, however, F. E. Kellogg, of Santa Barbara, Cal., who has been intimately associated with the growth of at least two of the pioneer orchards of the State, is firmly of the opinion that the profitable life of a walnut orchard may be extended to 35 years if the trees are planted 50 to 60 feet apart on good, well-drained soil. This statement is not intended to imply in the least that individual and scattered trees may not bear profitably much longer. In fact, so far as authentic records are available, the data that pertain to exceptional longevity, enormous size, and extraordinary yield relate to single, isolated trees.

It may be said in this connection that the foregoing opinions of Mr. Franklin and Mr. Kellogg are based upon their knowledge of the conduct of seedling trees, grown under the conditions existing in southern California. Notwithstanding the somewhat divergent views as to the period of profitable fruitfulness and the distance between the trees, the consensus of opinion is to the effect that in vigor, size, and longevity the walnut exceeds any other of our commercial orchard trees. As a crop for long-time investment under a suitable environment, it offers attractions and inducements that are scarcely equaled by any other. Acre for acre, few individual trees are required, thus minimizing the loss from individual weaknesses. Modern methods of propagation assure a uniform product. The steady increase in crop output until the trees have reached a considerable age (at least half a century) insures an accumulating income. The comparative freedom from serious enemies save one, the blight, reduces very materially the probable loss of crop or the serious reduction of quality values.

THE CROP AND ITS USES.

NUTS AS FOOD.

The chief uses of the walnut are as food, mainly dessert and confections, though during the past few years, with the growth of the movement looking to the introduction of a larger element of vegetable products into our dietary, it has become an important element in the composition of many substantial table preparations. Large quantities of the lower grade nuts grown in Europe are expressed for oil, but very few of the nuts grown in the United States are used for this purpose. Walnut oil is highly esteemed in France and in some instances is used in preference to that of the olive. It is also rated high as a drying oil for artists' use. In Europe considerable quantities of young walnuts are used for making pickles and catchups, and though inquiries for such preparations have been made recently in the United States it is found that they are not produced in commercial quantities from American-grown nuts. As an article of confection the smaller walnuts find a ready sale, and large quantities are annually consumed.

The first effort by an American firm to put the cracked nuts upon the market in commercial quantities was made with the crop of 1910, when a Los Angeles firm purchased large quantities of culls at $2\frac{1}{2}$ to $3\frac{1}{2}$ cents per pound and after putting them through an improved power cracker sold about 25 tons of assorted meats. The market price was 35 cents per pound for the unbroken meats and 28 cents for broken meats. The shells were sold for fuel purposes at 20 cents per sack. The very dark, black, and blighted meats were disposed of as stock food, though steps have been taken to ascertain whether

much of this low-grade material can not be used for making oil. In this connection an excerpt from the correspondence with this office of one of New York's largest and most exclusive importers and wholesale grocers, commenting upon the relative selling value of the American and French walnut products, may be pertinent to the topic under discussion.

We were interested in the American cracked product last year (1910) principally because we could get it about two weeks before the foreign nuts arrived. This enabled us to distribute before the Thanksgiving holidays, which is a season of large consumption. Later in the year when the foreign nuts began to arrive we purchased chiefly of these, as they were more uniform in size, whiter in color, and more carefully assorted. Some years, as in 1910, it is found that, of uncracked nuts, the Grenoble, which is the best of the foreign nuts, is of higher quality than the home-grown nut; in other years it is the reverse. With the cracked nuts there is little, if any, choice as to quality, though there may be considerable in the respects noted above. Seasonal climatic conditions apparently have much influence upon the quality of the walnut.

Of this last remark something more may be said at this time, since seasonal variations in the quality of the product seriously affect the commercial stability of the crop. A notable instance of this character has been observed in the two crops of Manchurian nuts that were imported during 1910 and 1911. The importation of 1910 proved to be a fair quality hard-shell nut that cracked well, while the crop of 1911 was exceedingly disappointing, especially to the importers, who were losers by the transaction. The crop of 1911 cracked badly and, besides, yielded a larger percentage of poor-quality nuts as compared with the 1910 crop. Similar experiences followed the importation of Chilean nuts, which were formerly imported in considerable quantities. Even with the European crop there are wide variations in quality from one year to another.

OIL.

Thus far, little effort has been made to convert the American product into oil, probably owing to the fact that heretofore the quantity of inferior nuts has been very limited, or at least in the process of grading they have not been separated from the better quality nuts.

With the closer grading that will inevitably accompany an increased output, a higher price scale, and a more systematic handling of the crop there will be a distinct and appreciable quantity of culls that must be utilized; hence, the importance of an establishment for the conversion of the low-grade material heretofore of uncertain market value into products of recognized market ratings of moment.

For the past 20 years a grower in the southern California district has annually converted about 1,200 pounds of culls into oil for home use, and finds that each year it is increasingly appreciated

as an article of food and medicine. As a result of this experience in expressing oil from the California product the following data are offered those who would utilize the culls. Good oil can be made only from sound nuts, though in commercial terms they may be culls. In other words, rancid, moldy, or partly decayed meats are not suitable for oil making. The nuts must be thoroughly dry before being expressed. Nuts, the kernels of which have been blackened through sunburn, are suitable for oil making, and such oil will be good, provided it is carefully clarified. The best oil is obtained from kernels that are plump and white, or at least of light color. Of the several varieties tested by the grower referred to, the Placentia has given the best results. A sack of the culls of this variety as offered in its home district, Orange County, Cal., weighs about 50 pounds and cracks about 25 pounds of meats, which expressed for 24 hours will yield 12 pints of excellent oil. For average culls, all varieties and one year with another, 25 pounds of meats yield 1 gallon of oil. Culls usually yield from 15 to 20 pounds of meats for each 50 pounds of nuts. Shriveled meats are as good as plump ones, but the quantity of oil in them is less. Oil experts have pronounced the oil from the soft-shell superior to that from the hard-shell varieties, though pound for pound the kernel yield is about the same. In any event care and cleanliness must be exercised in making the oil; otherwise the quality of the meats will count for naught. Under present conditions nuts are more profitably sold at 10 cents per pound than expressed into oil.

PICKLES.

Large quantities of immature walnuts are imported into the United States from Holland and England for use as pickles, catchups, sauces, and flavoring material. The nuts after being processed and barreled in brine are shipped in 70-gallon casks at a cost to the importer of \$15 to \$18, duty and freight included. There is no doubt that this part of the market demand for walnuts could be supplied by our own growers if on trial the cost of production permitted.

For pickling, the nuts are gathered when tender enough to be easily pierced by a large pin. At this stage they are entirely free from woodiness, a prime requisite for high-quality pickles. When picked the nuts are placed for nine days in a brine consisting of 4 pounds of salt to 1 gallon of water, renewed on the third and sixth days. On the tenth day the walnuts are removed from the brine and exposed to direct sunlight about two days until perfectly black. Sometimes the nuts are treated with dry salt instead of brine. This treatment, it is claimed, blackens them without exposure to sunlight. After the nuts are fully blackened they are placed in clean, dry jars

and covered with hot, spiced malt vinegar, to each quart of which are added 2 ounces of whole pepper and 1 ounce each of allspice and bruised ginger root. Sometimes a few shallot onions are added to the boiling vinegar. After the jars are filled and the tops screwed down they are placed in a cool, dry room and in a month are ready for use, though they may be kept for 3 or 4 years.

Taken at the same stage of growth as for pickling and boiled in a rich sirup, walnuts are said to make a delicious and delicate sweetmeat.

DISTRIBUTION AND AREAS OF CULTURE.

CULTURAL RANGE.

As indicated by its variable natural habitat, the walnut may be grown over an extended area, though the profitable production of a high-class nut is confined to relatively narrow limits in a few widely separated regions—France, Italy, Germany, Austria-Hungary, Russia, China, Chile, and the United States. Though grown with commercial success in these countries, it is only in restricted areas of each that the choicer grades are produced, notably in the Grenoble district, France, in the vicinity of Sorrento, Italy, and in southern California.

That this nut is not grown successfully over a more extended area has been largely due to the absence of a thorough effort at improvement and adaptation, there having been practically no advance in varietal improvement since the origin of the Franquette, over 100 years ago. Likewise, there has been only one notable instance of adaptation through selection, the Santa Barbara soft-shell, unless we take cognizance of the recent evidence of blight-resistant varieties in southern California. Within the past five years considerable impetus has been given the idea that the area of profitable walnut culture in the United States may be largely extended through the employment of other stocks than its own upon which to work the choicer and more hardy varieties of the Persian. Careful consideration of varietal requirements and adaptation by selection materially advance the view that the walnut may be commercially grown over a considerably wider area than was formerly supposed.

Various though not extended tests demonstrate that several of the leading commercial varieties of *Juglans regia*, the Persian walnut, when worked upon the American species *J. nigra* and *J. californica* may be successful in regions where formerly the Persian was a failure. The native stocks being more resistant to drought, heat, excess of moisture, alkalis, and unseasonable and severe changes in temperature, makes it possible to utilize a much greater range of soil and

climatic conditions than has been deemed possible. Not only has the work with the American stocks given excellent results, but some very remarkable developments have followed the work of top and crown grafting upon certain hybrids originating in California, notably the Paradox and Royal. The Paradox is the offspring of a cross-pollination between *J. regia* and *J. californica*, while the Royal is the offspring of a cross-pollination between *J. nigra* and *J. californica*. These hybrids are characterized by an extraordinary vigor of growth, in many instances a year's growth of 12 to 15 feet as against half as much in the parents. Like the native species, these hybrids are hardier than the Persian walnut and not so subject to injury by early spring changes in temperature, which, through starting and checking a premature flow of sap, seriously damage the younger wood and blossoms. Grafted upon these hybrid stocks, the Persian walnut makes a remarkable growth and so far as tests with them have been made gives promise of early and abundant fruitfulness.

Serious defects appear in these hybrids in that while a few trees are reported prolific they are generally indifferent bearers and that the seedlings grown from the nuts vary greatly in vigor, in some instances not over 20 per cent being first class. Though this makes it necessary to grow a large number of seedlings for a small quantity of first-grade stock, some propagators consider the expense repaid by the exceptional vigor of the seedlings, surpassing the native blacks or the Persian. This view is strengthened by the observation of F. A. Leib, an extensive experimenter in the propagation of the walnut, who says:

On the root depends the entire success of the orchard, and after an extended investigation we are convinced that the nuts of certain of our hybrids produce trees that surpass all others in sturdiness, adaptability, and rapidity of growth.

Of Mr. Leib's statement it may be said that, while he attaches great importance to the value of the root, or stock, and his words even imply that the whole credit of successful growth is due to the root, in his own practice he uses every precaution in the selection of scions, thus doubly insuring the production of a successful tree.

Mr. Payne, an observer, propagator, and grower of the walnut, is of the opinion that the merits of these hybrids are not yet fully determined. He says:

I have noticed that in dry seasons the Paradox seems unable to furnish as much moisture for the development of its crop as the native California black growing under the same conditions. The nuts in the instances observed were considerably smaller on the Paradox root than on the native black, and I ascribe this result to a shortage in the water supply. Of the seedlings from the two hybrids, those of the royal are by far better, though they vary widely in general character as to vigor of growth, foliage, and resistance, while some of them when grafted refuse to unite with the Persian scion.

Mr. Payne's observation is not yet verified by other propagators, and it is possible that local conditions may have been a determining factor in the results observed by him. Should his observation as to the inability of the hybrids to endure drought become established a great part of their prospective value as stocks would be lost and the native black walnuts would be the sole reliance upon which to predicate the future extension of the area of walnut orcharding in the United States.

RANGE BY STATES.

Alabama.—"The walnut has not been grown in this State with any degree of success, except in a small way. So far as the product of the tree is concerned, it is usually strong flavored and early becomes rancid." (*P. F. Williams, Alabama Agricultural Experiment Station.*)

Arkansas.—"It is reported that an English walnut tree near Little Rock has been fruiting for several years, and it is recommended that it be tried further in the cotton belt." (*Arkansas State Horticultural Society, Report, 1910.*)

Colorado.—"One tree of the walnut, variety unknown, is successfully growing near Boulder, on the mesa near the foothills. There are no commercial plantings of this nut in the State to my knowledge." (*D. M. Andrews, Colorado.*)

District of Columbia.—In various parts of the District of Columbia are to be found large, thrifty seedling trees of the Persian walnut, but as far as examined, with one exception, the Barnes, the fruit is of indifferent size and quality. The climatic conditions are such that the trees do not bear regularly, though in the case of the Barnes it is reputed to be a good bearer, considering its immediate environment.

Florida.—"It is agreed on all hands that *Juglans regia* has failed in Florida. Many report that the trees die before bearing, though I have heard of some that bore. It is not recommended by any of the nurserymen of the State. *J. cordiformis* and *J. sieboldiana*, on the other hand, flourish well in north Florida and bear profusely. But the shells of their nuts are so hard and thick that there seems no prospect of their fruit rivaling the thin-shelled varieties of *J. regia* as a commercial product. Of the two, *J. cordiformis* seems preferable. I am unaware of any attempt to grow Japanese walnuts on a commercial scale in Florida." (*John Belling, Florida Agricultural Experiment Station.*)

Georgia.—"In 1908 and again in 1910 we made an extended inquiry of southern planters and nurserymen as to the success of the walnut in the South. After giving the reports of their various correspondents careful consideration we can not recommend the planting of the English walnut for commercial purposes this side of the Rocky Mountains." (*P. J. Berckmans Co., Georgia.*)

Indiana.—Though a few trees of the walnut are reported as successfully fruiting in Indiana, no especial effort has been made to give it a thorough trial. During the past year, however, one or two enthusiastic citizens of the State have undertaken to give the subject an extended experimental test.

Louisiana.—"About 15 years ago I planted grafted trees of several varieties of *Juglans regia* obtained from Felix Gillet, of California. The stock used was *regia* and these trees are now all dead, although the Mayette tree lived until two years ago and had attained a height of 20 feet, with a trunk 5 or 6 inches in diameter. This tree bore pistillate flowers for several years, but set no fruit. I now have a Mayette tree, top-budded on black walnut, which seems healthy,

as does another of the Gillet varieties similarly worked. About the time that I planted the Gillet trees, Luther Burbank sent me a number of seedling trees of the Santa Rosa. One of these is still alive, but not more than 4 feet high. The native black grows and bears well here." (*B. M. Young, Morgan City, La., 1910.*)

Maryland.—"Maryland, except the two westernmost counties, and Delaware have been producing fairly good seedling Persian walnuts for 100 years, and there are many young, middle-aged, and very old trees with good bearing records. The soil and climate are adapted to hardy types of the Persian walnut, and a lively interest has been created in nut culture in these States in the last five years. A good many young walnut trees are being planted." (*C. P. Close, Maryland Agricultural Experiment Station.*)

Massachusetts.—"It can hardly be said that it [the Persian walnut] can be grown successfully in this State, although it is possible that a specimen growing in a particularly favorable location may live to become of considerable size." (*William P. Rich, secretary, Massachusetts Horticultural Society.*)

"It [the Persian walnut] does not succeed here [Amherst], and I know of no place in the State where it does." (*F. A. Waugh, Massachusetts Agricultural Experiment Station.*)

Michigan.—"I have a 16 or 17 year old Persian walnut tree that has borne every year for the past seven years. I also have trees 6 years old raised from nuts off this older tree, and I believe they will bear in another year. The parent tree is 26 inches in circumference and about 20 feet high." (*F. P. Andrus, Michigan, 1911.*)

Many other trees of this species, *Juglans regia*, have been planted in this State, if the records of nurserymen's sales may be relied upon, but we have been unable to obtain any record of their bearing.

Montana.—"The only English walnuts being tested in Montana, so far as I know, are a few varieties planted on our substation grounds at Corvallis. These have been out two years and have made a very unsatisfactory showing. Two or three trees out of 30 or 40 are alive at this time." (*O. B. Whipple, Montana Agricultural Experiment Station.*)

Nevada.—"To my knowledge, there is only one tree of the Persian walnut growing in the State of Nevada. This tree is somewhere between 15 and 20 years old and is growing near Franktown, Washoe County. It is about 60 feet high, with irregular branches, and bears abundant crops about once every four years and misses a crop about one year in seven. The nuts are smaller and have harder shells than the ones usually bought in stores." (*P. Beveridge Kennedy, Nevada Agricultural Experiment Station.*)

New Mexico.—"In New Mexico no record has been made of the planting of the walnut, yet *Juglans rupestris* grows naturally in several sections of the State, while *J. californica* is growing and fruiting successfully on the grounds of the experiment station." (*Fabian Garcia, New Mexico Agricultural Experiment Station.*)

New York.—Many trees of the Persian walnut are fruiting in this State, especially in the region tributary to Lake Ontario, about New York City, and on Long Island. Several of the older trees have yielded profitable commercial crops for the past 20 years. Recently many seedling trees have been planted throughout the State, and a few grafted trees are also being tried.

North Carolina.—Reports state that there are a few walnut trees growing indifferently in North Carolina,

Ohio.—"I do not know that any attempts are being made to grow the walnut upon a commercial scale in this State." (*W. Paddock, Ohio Agricultural Experiment Station.*)

Individual trees, however, have been reported as growing and bearing successfully in various parts of the State.

South Carolina.—"Though numerous plantings of the walnut have been made in South Carolina, there are no records of successful croppage. Even the particularly hardy *Juglans sieboldiana* is reported as not hardy enough for the conditions in this State, though *J. nigra* thrives and bears abundantly at an early age in various parts of the State." (*A. G. Shanklin, Clemson College, S. C.*)

From other sources it is learned that the tree appears to be hardy enough in some localities, but that it fails to set fruit.

Tennessee.—"A great many Persian walnut trees in this State are planted in gardens and lawns, but no one, so far as I know, has attempted an orchard of them. Some trees at Hermitage bore the first time about three years ago." (*C. A. Keffer, Tennessee Agricultural Experiment Station.*)

Texas.—"In 1903 we planted several trees of English walnuts at this station, but our results have been entirely negative in character. The trees made a very poor growth, and all but one died inside of four years. This one is still living, but has made only a low, scrubby growth—less than 5 feet—and has not fruited. Judging from our experience, I doubt if they are suited to this vicinity." (*W. S. Hotchkiss, Texas Agricultural Experiment Station, Troup, Tex.*)

Virginia.—"So far as I am aware, the walnut is not grown in a systematic way in Virginia, though there are scattered seedlings in various parts of the State." (*H. S. Price, Virginia Agricultural Experiment Station.*)

Washington.—"The first walnuts planted in this part of the State were set out in 1896. In this first planting there were 15 trees (this tract has increased until at present there are 175 trees), all seedlings. They have grown vigorously and have been bearing good crops of nuts of variable quality since they were 6 and 7 years old. One of them, for which H. E. Van Deman suggests the name of Chelan, is considered to be a very promising variety. There are now about 30 acres of planted walnuts in this section." (*W. P. Shepard, Lake Chelan, Wash.*)

In the southwestern part of the State, especially in the vicinity of Vancouver, this tree has been growing and fruiting for approximately a quarter of a century. Not only have the trees of the Franquette and Mayette varieties been yielding excellent returns, but several local seedlings have been developed, two or three of which promise to be even better than their parents, the original varieties stated above.

In various parts of New Jersey, Virginia, and West Virginia vigorous, thrifty seedling trees are to be found. Several of these trees produce quite regular crops of nuts of more than passing merit. Most of them, however, yield nuts of inferior quality, and the chief value of the trees lies in the fact that they afford ample proof that the walnut can be grown in these various districts with measurable success. Top-working these trees with wood from hardy varieties of good quality would probably result in converting what is at

present a crop of inferior quality and small value into one of choice quality and highest market price, though it is certain that much better returns would follow the top-working of the native stock in the same or similar localities.

CLIMATIC CONDITIONS REQUIRED IN WALNUT GROWING.

The walnut is quite sensitive to changes in temperature during the early stages of the vegetative period and while the tree is young. It demands a climate that is temperate, relatively mild, and invariable. It is averse to wide ranges of temperature and great humidity, and yet it will endure without damage considerable rigorous winter weather during its dormant period, and even during the annual vegetative periods of its later life it will tolerate climatic variations such as would greatly injure young trees.

This tree suffers less from the severe cold of winter than from the frosts of late spring or early fall. Intense winter cold may split open the trunks and large branches, but serious damage is unlikely where the native walnuts range or in the relatively mild climate of the Pacific Northwest, especially if the stocks used are the native black walnut. The walnut ranges over a considerable area, under varying climatic conditions, but the leading commercial varieties, especially in the United States, grow within a comparatively restricted climatic environment. In that part of France where the highest grade of the commercial product, the Grenoble walnut, is grown, the climate of spring and summer is somewhat cold and the winters rigorous. The mean annual temperature of Tullins in the valley of the Isere, the heart of the nut-producing area of France, is from 45° to 50° F. The rainfall for the district is most abundant during the spring and autumn and averages about 40 inches for the year.

The data in Table I, based on what French writers consider the relationship of climate to successful walnut culture, present a compact view of the climatic conditions in those districts of the United States which produce nuts in commercial quantities, as well as in a few districts where isolated trees or small orchards have borne profitable crops for several years. Considerable of the data given apparently warrants the belief that so far as climate is concerned the area of successful cultivation may be greatly extended; but climatic conditions are not alone essential to success. Quite as much depends upon the careful selection of varieties, and hardiness is only one of the qualities required. The ultimate product, the nut, must be of pleasing outline, regular and uniform in size, with a bright, rich, yellowish-colored shell that is thin and firmly sealed. It must possess a kernel that is crisp, sweet, light colored, and with little or no astringency or bitterness. It should be high flavored, fine grained,

rich, and heavy. The tree must be a vigorous grower and must yield regular and abundant crops. It must be a self-pollinator and not too early. It must carry its blossoms through an extended period and be practically blight resistant.

TABLE I.—*Climatic and other data of important walnut-growing areas.*

	France.	California.			Oregon.		Pennsylvania.		New York.	
Climatic and other data.	Grenoble.	Los Angeles.	San Jose.	Santa Barbara.	Portland.	Albany.	Erie.	York.	Rochester.	Appleton.
Latitude.....	45° 30'	34° 3'	37° 20'	34° 23'	45° 32'	44° 35'	42° 7'	39° 50'	43° 8'	43° 20'
Elevation.....feet..	1,000	287	95	130	32	224	658	385	468	270
APRIL.										
Temperature (° F.)										
{ Monthly....	51	60	56	58	51	51	45	50	45	44
Mean { Maximum....	68	70	.....	67	60	59	56	62	53	54
{ Minimum....	39	49	.....	48	42	42	42	39	36	35
Absolute { Maximum....	85	99	87	95	89	84	94	94	90	84
{ Minimum....	27	38	29	38	28	30	16	16	11	16
Precipitation, inches:										
Mean.....	3	1.1	1.4	1.2	3.2	3.6	2.4	2.6	2.4	2
Annual.....	40	15.6	14.8	16.6	45.6	44.2	39.2	41.9	34.5	32.7
MAY.										
Temperature (° F.):										
{ Monthly....	58	63	60	60	57	57	57	64	57	55
Mean { Maximum....	68	73	.....	69	67	69	65	73	66	65
{ Minimum....	40	52	.....	50	48	46	49	50	47	44
Absolute { Maximum....	94	103	104	100	99	93	91	95	93	94
{ Minimum....	32.2	40	32	40	32	32	31	31	28	26
Precipitation, inches:										
Mean.....	4.25	.5	.6	.4	2.4	2.6	3.6	4.3	3	2.9
JULY.										
Temperature (° F.):										
{ Monthly....	69	71	67	65	67	67	71	75	71	70
Mean { Maximum....	81	83	.....	74	78	82	78	86	80	80
{ Minimum....	56	59	.....	56	56	51	64	53	62	59
Absolute { Maximum....	97	109	100	96	102	103	94	107	99	98
{ Minimum....	47	49	41	48	45	39	47	43	45	40
Precipitation, inches:										
Mean.....	4.33	.....	0	0	.6	.3	3.1	4.1	3.1	4.2
AUGUST.										
Temperature (° F.):										
{ Monthly....	68	72	67	67	66	67	69	73	69	67
Mean { Maximum....	83	84	.....	75	77	82	77	84	78	77
{ Minimum....	59	60	.....	58	55	51	62	61	60	58
Absolute { Maximum....	101	106	101	97	97	101	94	102	97	97
{ Minimum....	45	50	42	52	43	42	47	42	43	41
Precipitation, inches:										
Mean.....	3.8	.....	.....	0	.7	.4	3.2	4.1	2.9	3.1
SEPTEMBER.										
Temperature (° F.):										
{ Monthly....	50	70	65	66	61	60	64	66	63	61
Mean { Maximum....	55	82	.....	74	71	72	60	77	72	71
{ Minimum....	51	57	.....	56	51	48	46	55	53	52
Absolute { Maximum....	96	106	99	98	93	97	87	95	98	96
{ Minimum....	37	44	37	49	36	32	23	20	34	31
Precipitation, inches:										
Mean.....	2.6	.....	.2	.2	1.8	2	3.6	3.8	2.3	3.2

TABLE I.—*Climatic and other data of important walnut-growing areas—Continued.*

	France.	California.			Oregon.		Pennsylvania.		New York.	
Climatic and other data.	Grenoble.	Los Angeles.	San Jose.	Santa Barbara.	Portland.	Albany.	Erie.	York.	Rochester.	Appleton.
OCTOBER.										
Temperature (° F.):										
Mean { Monthly....	48	64	60	63	54	53	53	53	51	50
Maximum....	52	76	-----	72	62	64	48	64	59	60
Minimum....	37	52	-----	54	46	43	35	42	42	42
Absolute { Maximum....	84	102	93	96	83	84	74	88	87	88
Minimum....	37	40	32	47	31	29	26	20	19	24
Precipitation, inches:										
Mean.....	5.6	.8	.9	.8	3.6	3.4	3.8	3.1	2.8	2.4
DECEMBER.										
Temperature (° F.):										
Mean { Monthly....	34	56	50	56	42	41	43	43	29	30
Maximum....	37	67	-----	68	47	47	39	52	35	36
Minimum....	35	46	-----	45	37	37	26	34	22	23
Absolute { Maximum....	64	89	78	84	65	63	70	77	70	66
Minimum....	65	30	22	32	3	18	-11	10	-11	-2
Precipitation, inches:										
Mean.....	3	3.3	2.6	3.2	7.4	7.8	3.1	3.4	2.9	2.5
JANUARY.										
Temperature (° F.):										
Mean { Monthly....	36	54	48	53	39	39	27	33	24	26
Maximum....	42	64	-----	64	44	45	34	42	31	32
Minimum....	32	44	-----	44	34	34	20	25	18	19
Absolute { Maximum....	63	87	78	84	62	62	73	68	66	59
Minimum....	-2	30	18	28	-2	10	-15	-1	-12	-2
Precipitation, inches:										
Mean.....	2	2.8	2.7	3.7	6.6	6.7	3	3.1	3.2	2.6

Table I shows that southern California is remarkably exempt from freezing. Practically all the commercial crop in the United States is produced in this district with its mild, equable climate and deep, fertile soil. Extensive plantings of the Persian walnut are being made in other districts, notably in the Santa Clara, San Joaquin, and Sacramento valleys of California and the Umpqua and Willamette valleys of Oregon. Limited plantings are also being made in several other localities in the Pacific Coast States and in some of the Eastern States—New York, Pennsylvania, New Jersey, Delaware, and Maryland.

Though the Santa Barbara soft-shell walnut is the type of our present commercial output and the one variety most successful in southern California, its prestige may be due to the fact that no other variety has been generally tried in that district. Its early and continued financial success prevented the development of any better variety until the time of the blight invasion a few years ago. Now there is a decided effort to find a variety with the merits of

the soft-shell that shall be blight resistant. It is quite possible that out of this inquiry, which is certain to be an exhaustive one because of the great value of the crop, there will come a new type, or at least one more definite and uniform. While other districts are selecting hardier varieties, southern California, in seeking those that escape the late spring frosts, aims to insure not alone the production of a crop, but also to provide immunity to blight. By a judicious selection of late-vegetating varieties and by top-working upon native stocks, growers may successfully produce choice varieties of Persian walnuts under a much wider range of climate and soil than formerly was possible. Types like the French Franquette, Mayette, and Parisienne appear to be worthy of extended trial in the valleys of northern California, the higher elevations in the interior of the same State, and the western valleys of Oregon and Washington. Among promising varieties worthy of trial in this territory are Eureka, Prolific, Treyve, and Meylan. Certain growers report that Treyve and Meylan are rather shy bearers, which may prove a serious defect in these otherwise good varieties. Types of more or less uncertain parentage, as the Cumberland, Hall, Holden, Milbank, Mount, Nebo, Pomeroy, and Rush, appear to be especially adapted to New York, Pennsylvania, New Jersey, Delaware, and Maryland, and the effort now being made to propagate the more promising of them upon the eastern black walnut bids fair to greatly stimulate the interest in walnut culture in portions of the eastern United States. There is little reason to doubt that several of these varieties may be successfully grown and fruited if proper provision is made for pollination.

To what extent the introduction of grafting upon these hardy stocks will change the practice of growing seedlings from fruit of mediocre merit is as yet uncertain. Very little grafting has been done where only individual trees or small groups about the home grounds are grown from hardy seedlings, as in Michigan, Ohio, Indiana, Illinois, New York, Connecticut, New Jersey, Delaware, Maryland, West Virginia, Virginia, North Carolina, South Carolina, Georgia, Texas, Colorado, and Idaho. In Texas and Maryland considerable interest is being awakened through the work of private experimenters and the experiment stations. The range of country covered by the above list of States shows the possible area over which the walnut may be grown. In most instances only very indifferent success commercially has been attained with seedling trees of the Persian walnut. California and Oregon are exceptions, and here the day of the seedling tree is past save as an effort to obtain a new variety. The orchards of the future will be grafted trees of varieties selected to meet the local climatic environment.

SOIL REQUIREMENTS FOR WALNUT ORCHARDING.

The walnut delights in a deep, moderately cool, moist soil, mellow, alluvial, and rich in humus, but it succeeds well upon clay loams, sandy loams, gravelly loams, or friable clays (such as the so-called shot clays of the Pacific Northwest) when the surface soil is well drained and possesses a liberal humus content and the water table is at a depth of 16 or more feet. For the growth and maintenance of large, long-lived trees, one thing is essential: The soil must be deep, 2 to 3 or more feet, and have a porous subsoil from 8 to 12 or more feet deep, and in no instance should hardpan, bedrock, or impervious clay be at a less depth than 16 to 20 feet. The most vigorous and productive walnut orchards in France and California are found upon the deep, cool, well-aerated, alluvial soils of the valleys, and especially upon slight elevations above the main valley floor.

A moderate lime content is a desirable feature of any soil upon which the walnut is to be planted for commercial purposes. Soil that is held to be good for orchard and garden crops may be considered suitable for walnut trees, provided it is sufficiently deep, well-drained as to air and water, and of an elevation sufficient to escape the early autumn and late spring frosts.

A soil composed of small to medium sized gravel mixed with 15 to 40 per cent of fine sand and clay and 1 to 2 per cent of lime makes an excellent host for the walnut tree. The reddish brown alluvial soils of the Pacific coast, rich in iron oxids, when overlying a gravelly, sandy subsoil, are among the best for walnut growing, as they are usually cool and supplied with moisture which thorough tillage and the use of the soil mulch will conserve. These soils are friable and rather coarse grained, fertile, well aerated, deep and retentive, and very responsive to all active tillage.

In the Eastern States, so far as present data show, it may be said that the Persian walnut flourishes on all soils upon which the black walnut is found, and under favorable conditions on some others. In fact, reports from 9 or 10 States say that the walnut will grow satisfactorily upon any good soil if it is deep, sufficiently well drained, aerated, and possesses a low water table. Sandy loams, clay loams, gravelly loams if not too open, and sedimentary deposits are all, separately or mixed, equally suitable for the growth of this tree.

FACTORS IN LOCATING A WALNUT ORCHARD.**LOCATION.**

In some respects the problem of locating a walnut orchard is not difficult. The product being extremely hard, compact, and long keeping, it is not essential that railroad facilities be in the immediate

vicinity. Wherever there are passable roads, suitable soils, a fit site, and congenial climate a walnut orchard may be located with quite as much assurance of success as if it were close to a great transportation system or a ready market. If, during the first few years, the grower desires to raise intercrops their importance may be a factor in determining the location. The selection of varieties and the necessity of early marketing affect the problem, since dealers desire the product for the Thanksgiving market. Labor for harvesting has likewise to be carefully considered, especially where large areas are contemplated or where fall rains occur during the period of harvest. Should the walnut harvest come at the same time with other crops it seems desirable that the location should be near a center of population.

SITE.

In a general way it may be said that the walnut requires a site that will insure it protection from excessive heat, cold, wind, drought, and moisture. An ideal site is one that affords protection against the undue stimulating influences of warm days in early spring, the ravages of early autumn frosts, the desiccating effects of drought, the distress of a water-logged subsoil, and the parching heat of a midsummer sun. To what extent it may be possible to secure all of these desirable features in a particular site will depend upon the prevailing climatic and topographic conditions.

European writers consider a western exposure best, and gentle slopes of moderate elevation better than valley floors, higher hills, or plains. Especially should the lower levels of the valleys be avoided if the air is damp and the soil cold and heavy. While the walnut demands a soil with plenty of water, it requires at the same time a dry atmosphere without too much heat. In some instances the fault of a site may be overcome through the selection of suitable varieties. Where an intense summer sun would damage the nuts by burning, partial or entire exemption may be secured through the selection of a variety with an abundance of foliage; where late spring frosts occur injury is reduced to a minimum by selecting late varieties. Only when it is impossible to secure a first-class site should one give a moment's consideration to other than the best varieties, such as by early maturity, prolificness, self-fertility, or a heavy oil content may yield a crop of substantial value.

In the coast valleys of southern California damage from spring and autumn frosts is almost unknown, though occasionally trees growing too late in the autumn have been injured by an unusual cold wave. Cold autumn rains rarely damage the crop and are not to be considered a serious menace. Under such conditions little difficulty will be encountered in selecting a site. Any place that presents a

suitable soil and water supply is acceptable. Low-lying valley lands and river bottoms, so long as their soils are not cold with excess of water, and gently rolling lower benches are equally suitable. Almost universally the more fertile soils of this region occupy the floors of the valleys and the river bottoms. Occasionally, however, the soils of the lower levels are close, heavy, cold, and poorly drained, so that the more suitable site for a walnut grove may be upon the first benches or at the head or margin of the valley floor. In the interior valleys and plains so little has been done with the walnut that anything in the way of specific direction as to site would be mere assumption.

Early and late frosts, hot, dry winds, and intense sunlight are of such importance that each planter must decide his own case according to the facts before him. Protection from winds, excessive heat, and extra-seasonal frosts should be chief considerations in all plantings. As a protection against winds one may select the lee side of a mountain or timber belt; against frosts, an elevated site with good air drainage or a wind-protected vale where orchard heaters may be used in case of need; and against excessive sunlight, trees with dense foliage or nuts with heavy hulls, or both. For the information of the inexperienced it should be said that upon this phase of the subject few facts are at hand, as the possibility of cultivating this tree with commercial success under the conditions that exist in the interior valleys of California has received attention only within the past few years.

In the more northern Pacific coast regions, especially in the valleys of western Oregon, which appear particularly well adapted to the production of a high-grade nut, it is necessary to exercise considerable care in the selection of a site. These valleys have equable climate, congenial soil, and abundant moisture, coupled with sufficient drainage, but occasional frosts in late spring or early autumn damage the crop or even the trees if not properly situated. In some seasons the fall rains retard the maturing crop and increase the staining of nuts from contact with the soil. A judiciously chosen site should provide thorough soil drainage, generous exposure to direct sunlight, and a free circulation of air.

VARIETIES AND TYPES OF WALNUTS.

To-day the leading walnut upon the world's markets is the Grenoble, grown in the valley of the Isere, a river having its source in the foothills of the western Alps in southeastern France. Strictly speaking, the Grenoble nut means the Mayette variety, though the term sometimes includes the Franquette and Parisienne varieties grown in the same section. The leading product of the American

walnut orchards, supplying about one-third of the quantity consumed in the United States, is the Santa Barbara, a soft-shell nut that originated with Joseph Sexton, Goleta, Cal., some 40 years ago and is reputed to be a seedling from a nut imported from Chile. Though this variety (more properly type, if one considers uniformity of product) constitutes something like 90 per cent of the home-grown walnuts marketed in the United States, several other varieties possess high merit. Some of these varieties, notably the home-grown Franquette, enter the American market under their own names, and it is quite probable that several distinctive American varieties will be marketed in a few years. Herein is one of the most promising aspects of walnut growing—the development of the industry beyond a general product. As the apple orchardist during the last decade has passed from a grower of apples in general to a grower of specific varieties, such as the Winesap, Esopus, etc., so the walnut orchardist may anticipate a type of orcharding wherein the grower becomes a specialist, a producer of specific varieties for definite purposes or because of a special environment.

The possibility of producing and marketing a distinct type of nut, having its own particular merits or qualities, will add many attractions to an industry that heretofore has offered no especial incentive to the intelligent person looking for opportunity to develop a special product. Such development of varieties will be a necessary result of the climatic requirements of the northern Pacific coast, quite different from those giving the best results in southern California, and still more so from those yielding partially satisfactory results in the Eastern States. That it is possible to develop varieties particularly adapted to the requirements of these separate districts is no longer considered doubtful by advanced workers in nuciculture. To this end substantial aid is expected from investigations now being conducted by nurserymen and enthusiastic growers with the late-blossoming varieties and hardy stocks in both the Eastern and Pacific Coast States. The California experiment station at Whittier deserves especial credit for arousing interest throughout the State in the effort to develop better varieties, to improve the methods of culture, and to plant grafted trees instead of seedlings.

Of the extended list of varieties of Persian walnuts that have been catalogued, few are of commercial importance in the United States. In this survey of walnut growing, it has been the purpose to consider every variety that appears to possess active or latent possibilities of adaptation and development by which the area of cultivation may be extended. So far as it has been possible to procure home-grown specimens of the several varieties, they have been subjected to critical examination and comparison in order to establish

a uniform and amplified description, such as would enable even a novice to identify typical specimens of varieties of record. It has been impossible within the available time and means to procure specimens of all varieties reported to have been grown in the United States, and in a few instances we were unable to procure sufficient specimens upon which to base a complete description, e. g., of Cosine, Honeydew, Nebo, and Parry. The first, Cosine, is an indifferent variety, reputed to have originated in Oregon from a Chilean nut, and is of historic value only. The other three, and especially Honeydew, are worthy of trial. Nebo is an eastern seedling and may possess little merit for Pacific coast planting. Honeydew is a superior Mayette, so far as outward appearances indicate, and promises to be especially suited to Pacific coast conditions, though it may thrive in the Eastern States when grafted upon the eastern black walnut.

The descriptions offered at this time are necessarily incomplete, since they are based chiefly upon specimens of the crop of 1910, which was a very severe year and an imperfect development of the fruit was generally prevalent. The hope is expressed at this time that originators and growers will advise the Department of Agriculture of the advent of new varieties or of changes in the conduct of established varieties as they are subjected to the influence of new environment, so that deficiencies in the descriptions may be corrected and printed later, with others that may then be given.

Nuts of the cultivated varieties of Persian walnut vary greatly in size, shape, color, and minor characteristics. Those grown in the United States are separated quite readily into varietal groups or types—Bijou, Mayette, Franquette, Chaberte, Santa Barbara, Sorrento, etc.—and for the purpose of facilitating classification 20 such types have been defined. So far as known this is more complete than any previous grouping of the walnut. Classification requirements are apparently best met by the French system, comprising five leading divisions as determined by (1) region, (2) location of growth, (3) precocity, (4) thickness of shell, and (5) use. Of the various groups, the following may interest American planters:¹

Varieties for lower level lands and plains: Chaberte, Common, Parisienne.

Varieties for hillsides and bench lands: Common, Cornes,² Chaberte, Fertile, Franquette, Hardshell, Marbots,² Mayette, Saint John, Vourey.

¹ Arthaud-Berthet, J. Culture du noyer en France. Annales de l'Institut National Agronomique, sér. 2, t. 2, 1903, pp. 19-144, 7 pls.

² Commercial types rather than specific varieties.

Varieties for dessert: Cornes, Fertile, Figeac, Franquette, Gaute-ron, Marbots, Mayette, Meylan, Nave, Parisienne, Thinshell, Vourey.

Varieties for confections: Candelon, Careme, Chaberte, Common, Small Round.

Varieties for oil: Bijou, Candelon, Careme, Chaberte, Cluster, Common, Double Kernel, Hardshell, Noisette, Saint John.

CLASSIFICATION AND DESCRIPTION OF VARIETIES.

The tentative scheme of classification here given is offered with a view to facilitate the study of varieties and types of the walnut grown in the United States, and may be of service in the effort to extend the area of successful walnut culture. The basis of the scheme is the structural resemblance of the nuts, an arbitrary grouping, only incidental consideration being given to botanical relationships; but this classification does, in effect, group varieties closely related, since the form and structure generally indicate varietal peculiarities within the several groups. In the future it may be possible to classify the varieties according to a more exact and natural scheme, but with the data available it appears impossible at present.

Names in *italic* indicate varieties which are types of their respective groups. No type is designated where, so far as ascertained, none exists in American orchards. The word "type" after the name implies that the variety described is the standard of that group. The name usually agrees with the type name, though in the case of Persian Long, Marbot, Sorrento, and Cahor there are no type varieties growing in the United States, so far as known.

SCHEME OF CLASSIFICATION.

BIJOU: *A'Bijou*, Acme, Alpine, Barnes, *Bijou*, Calavette, Gladys, Hall, Klondike, Mammoth, Payou, Peerless, Willson.

CAHOR: Chelan, Ward.

BRANTOME: Hays.

CHABERTE: *Chaberte*, Drew,¹ Papershell.

CHINESE: *Changli*.

CLUSTER: *Cluster*, Concord, Fertile (Gillet seedling).

COMMON: Weaver.

FERTILE: *Fertile*, Late Fertile, Mammoth Fertile.

FRANQUETTE: Franmay, *Franquette*, Mayquette, Vourey² (short).

HYBRID: Barthere, Paradox, Royal, Vilmorin.

LALANDE: Derby.

MAYETTE: Bennett, Chicotte,³ Columbus,³ Fertile (Gillet seedling), Grand Noblesse, Honeydew, *Mayette*, Mayette Blanche.

¹ Based upon illustration and description by Arthaud-Berthet, but not conforming to the type illustrated in Plate VI.

² Specimens of this variety sent in by the late Felix Gillet do not conform to the French type as described and illustrated by Lesourd.

³ Doubtful.

MARBOT: Holden, Mount, Pomeroy.¹

MEYLAN: *Meylan*.

MISSION: *Mission*.

MONTIGNAC:² Lea.

NAVE: Ellwood.

PARISIENNE: Milbank, Nebo, *Parisienne*, Rush, Sinclair, Treyve.

PERSIAN LONG: Chase (2), Eureka, Hale, Kaghazl (long), Keesling, Prince, Prolific, Stocktonian.

SANTA BARBARA: Chase (1), Ford, Journeay, Lane, Neff, Placentia, *Santa Barbara*, Santa Rosa, Sexton, Teague.

SORRENTO: Dean, Hubbard.

NOT CLASSIFIED.—The writer has been unable to see either specimens or written descriptions of the following varieties; hence, no attempt is made to group them: Ford's Mammoth, Hightstown, Longbeaked, Mobart, Parry, Poorman, Thinshelled, Volga, Weeping.

DESCRIPTIVE LIST OF VARIETIES.

In the following descriptive list of varieties of the Persian walnut the statements as to size are made by comparing the American-grown nuts with the average French Mayette. Upon this basis Cumberland and Rush are approximately typical of a medium-sized nut.

Technical terms used are chiefly from European writers and some have been adapted from modern systematic botany. For convenient reference a few are here defined:

Appressed. Ribs of the sutures not above the general surface of the shell.

*Convolution*s. The waving or folded rolls of the margins of the kernel.

Diaphragm. The thin, woody, membranous tissue that more or less distinctly separates the halves of the kernel.

Equator. An estimated horizontal region midway between the apex and the base, though in some instances, when considering the location of the pits at the sutures, it is deemed to be somewhat above or below a median line.

Flange. The face of the suture, varying in width with the different varieties.

Longitudinal lines. The more or less pronounced lines which pass from base to apex over the shell midway (or nearly so) between the sutures.

Mucronate. Having a suture tipped with a short, sharp, thin point.

Pellicle. The thin membrane that covers the kernel. It is the seat of the astringent and bitter principles that mark many of the American-grown walnuts.

Sutures. The more or less ribbed lines along which the two halves of the shell unite.

A'Bijou.

A name used by John Rock to designate a seedling of Bijou quite similar in form and size to the variety herein described as Klondike (p. 44), but having a much richer yellowish shell.

¹ The two lots of Pomeroy walnuts received for comparison differed so widely in general character that it is impossible to assign this variety satisfactorily to any one group. Nuts from one of the parent trees, crop of 1910, resemble the Common nut of France, while the nuts from seedling trees of the parent Pomeroy trees resemble very closely the Flégeac type. Until a more extended study of this variety is made it must remain unclassified, though Dr. Morris has stated that in his opinion it is a Marbot.

² After Lesourd.

Acme.

A large nut of the Bijou type, similar to the Willson; originated in the same section and at about the same time. Said by the introducer to be blight resistant.

Ailanthus Leaved.¹

Probably a synonym of *Juglans sieboldiana*.

Alexia.

A seedling originating on the property of Alexander Smith, Cecil County, Md. The tree is very vigorous and productive. The nut is reputed to be large and good. Exhibited at the meeting of the Northern Nut Growers' Association, Lancaster, Pa., 1912.

Alpine.

Bijou type; large; broadly oblong, angular and slightly tapering toward the base; base obtuse and rounded; apex obtuse with short mucronate point; sutures appressed toward the base and only slightly ribbed toward the apex, pitted at the equator; flange very firmly sealed; shell grayish yellow, roughened with numerous deep, irregular, variable pits and protuberances, usually two or more longitudinal lines well defined. *Origin*: France; specimens grown by Felix Gillet, crop of 1904.

Lelong, in his treatise entitled "California Walnut Industry," published in 1896, writing of this variety, says: "A new and very large variety that originated not long ago in the Alps Mountains of France. Next to the Mammoth it is the largest walnut grown on my place. Though the shell is rough, it is thin, and the meat sweet and filling well the shell."

Andrus.

A seedling originating with F. P. Andrus in Michigan. It is reputed to be a hardy tree on its own roots in that State.

Ash Leaved.

Synonym of Cutleaf.

Barnes.

Bijou type, modified; size above medium; obovate to roundish or occasionally nearly oblong; strongly four-angled, many specimens will stand quite erect upon apex; base obtuse to acute; apex obtuse-truncate, small mucronate tip usually depressed; sutures appressed, more or less depressed toward the base, usually two to four rather large, deep, widely separated and commonly oblique pits at the equator; flange narrow or even very narrow, firmly sealed; shell rather thick, grayish brown, sometimes slightly mottled, moderately smooth, though a few deep depressions and a few pronounced protuberances are present, veining ample, longitudinal lines usually well defined; diaphragm firmly shouldered, rather strong, and inclined to be persistent; kernel full, convolutions even, quite regular; pellicle brownish with slightly darker veins which are broad but not numerous, astringent; flesh firm, crisp, rather dry, fine grain; flavor sweet, pleasant; quality fair to good. *Origin*: Seedling trees growing upon the grounds of Theodore Barnes, in Washington, D. C.; first called to public attention in an exhibit at the Convention of Northern Nut Growers, Ithaca, N. Y., 1911, by T. P. Littlepage.

Barthere.²

A French variety introduced into the United States in 1871. Of this variety Mr. Gillet, the introducer, says: "A singularly shaped nut, elongated, broad at the center and tapering at both ends; the shell is harder than that of other varieties."

¹ Georgia Horticultural Society, 1900.

² Catalogue, Barren Hill Nurseries, 1887-88.

Bennett.

A variety reputed to have been produced from a nut purchased in New York City in 1874 by James L. Bennett, and grown upon his property at Unionville, Orange Co., N. Y.

Bijou.

Type; very large; oblong to more or less obovate and angular; base obtuse; apex obtuse to depressed, mucronate tipped; sutures appressed or even depressed especially toward the base, pitted at the equator and toward the apex, frequently pits form a continuous line over half the length of the suture; flange narrow, usually firmly sealed; shell brown, thickened by ridges and irregular protuberances, and strongly roughened by numerous pits and depressions, longitudinal lines occasionally well defined; diaphragm weak shouldered, thin, and scarcely persistent; kernel quite full, rather plump, convolutions moderate, very irregular; pellicle brownish yellow, dull, astringent; veins rarely noticeable; flesh moderately oily; flavor sweet, mild; quality good. *Origin:* Europe; specimens grown by Ely I. Hutchinson, crop of 1910. (See Pl. III.)

Burbank.

Synonym of Santa Rosa.

Calavette.

Bijou type; originated with E. M. Price, Westpoint, Cal. It is a cross between Bijou and Fertile. It is not recommended for sections in which late frosts occur, though it originated at an elevation of 3,000 feet in the Sierra Nevada Mountains.

California Papershell.

Originated by Felix Gillet from a nut borne on a grafted Chaberte tree. It is, therefore, a second generation Chaberte. The nut is only medium in size; shell very thin and almost white; kernel full fleshed, exceedingly sweet and nutty.¹

Chaberte.

Type; medium; oblong; base obtuse; apex obtuse, mucronate tipped; sutures appressed to very slightly ribbed, usually pitted at the equator; flange variable, usually broad, very firmly sealed; shell brownish, thick, slightly roughened with a few depressions and protuberances, longitudinal lines well defined; diaphragm firmly shouldered, thin, but somewhat persistent; kernel full, fairly plump, convolutions moderate, variable; pellicle brownish yellow, dull; scarcely astringent; veins very noticeable; flesh oily, rich; flavor mild, sweet; quality very good. *Origin:* France; specimens grown by Ely I. Hutchinson, crop of 1910 (Pl. VI).

A variety held to be of very general merit. In France it is considered a very suitable variety to plant on both foothills and valley floors; it is valued in Europe as rich in oil and for confections. It is rather late in vegetating in the spring. An objection to the walnut for confectioners' use is that the kernels are too large, but our planters may find it worth while to ascertain if the Chaberte or a similar nut can be advantageously grown in this country.

Changli.

(S. P. I. No. 17943.) Chinese type; large; roundish oblate; base obtuse truncate; apex obtuse to retuse truncate without point or tip; sutures appressed toward the base, slightly ribbed, broad and rounded above, more or less pitted at the equator; flange very firmly sealed; shell brownish yellow, somewhat roughened by depressions, usually slight, with few

¹ Lelong, B. M. California Walnut Industry. 1895-96.

pits, longitudinal lines, usually light and rather inconspicuous, though rarely altogether absent. (See Pl. II.) *Origin*: China. Specimens collected in the vicinity of Changli, Chihli Province, China, by F. N. Meyer.

Mr. Meyer, in Bulletin 204, Bureau of Plant Industry, entitled "Agricultural Explorations in the Fruit and Nut Orchards of China," writing of this variety together with others produced in the same locality, remarks: "In the vicinity of Changli, Chihli Province, there are some walnut orchards in which the trees vary to a remarkable degree. Some produce small, hard-shelled nuts of poor flavor, while others bear fine, large nuts, with a really fine flavor, and having shells so thin that they can be cracked with the fingers like a peanut. Between these extremes one finds many gradations in hardness of shell, size, and flavor. It is very likely that some kinds of these Chinese nuts may prove to be much hardier than our present Persian strain of walnuts and in all probability they will thrive especially well in certain sections of the southern Rocky Mountain region."

This Chinese type of walnut Mr. Meyer has designated as *Juglans regia sinensis*. The type is admirably illustrated in the above variety, to which, though reported by number, the writer has given the name Changli, to designate its source. As already indicated, the nuts are large, flattened at the ends, inclined to smoothness and full roundness, with sutures marked by peculiar broad and smooth, rounded ribs. The age of the specimens prevented determination of the value of the kernel at the time of describing the nut, but on the strength of Mr. Meyer's statement that the fine large nuts possess a really fine flavor, steps have been taken to import wood of this variety and others from the same district.

Chase (1).

Santa Barbara type, closely resembling the More form; large; broadly oblong and angular; base rounded, occasionally acute; apex obtuse or acute and strongly pointed; sutures usually strongly ribbed, rarely pitted at the equator; flange narrow, very firmly sealed; shell thin, grayish brown, roughened by various irregular depressions, longitudinal lines not infrequent; diaphragm almost weakly shouldered, thin, yielding, rarely persistent; kernel full, rather plump, convolutions moderate, even; pellicle rather dark, glossy, astringent; veins dark and rather well defined; flesh rather coarse, oily, rich; quality fair. *Origin*: A seedling from nuts imported from France by Felix Gillet and planted by Mr. Van Vorce near Whittier, Cal., in 1886; specimens supplied by A. R. Rideout, crop of 1910 (Pls. VI and X).

Chase (2).

Persian Long type; this type differs from the preceding in that the nuts are more narrowly oblong, smoother, and more regular, with appressed or very slightly ribbed sutures that are usually less firmly sealed; specimens supplied by A. R. Rideout, crop of 1910 (Pl. X).

This variety is indorsed by the University of California as worthy of extended trial by those in search of blight-resistant varieties.¹ The variety does not appear to be firmly fixed as yet, or else more than one form is being propagated.

Chelan.

Cahor type; medium to slightly above; oblong; base obtuse to slightly rounded; apex obtuse to acute with slight point; sutures very moderately ribbed, equatorial pits variable, often absent; flange very thin, firmly

¹ Bulletin 203, California Agricultural Experiment Station.

sealed; shell very thin but rather firm, yellowish or grayish brown, roughened with numerous irregular depressions and furrows; diaphragm weakly shouldered, thin, and scarcely persistent; kernel full, rather plump, convolutions moderate and variable; pellicle dark yellowish brown, semi-glossy, very astringent; veining inconspicuous; flesh crisp, rather dry; flavor sweet, mild; quality fair. *Origin*: Chance seedling in Springdale Orchards, Lakeside, Wash., 1899; specimens grown by D. H. Hulseman, crop of 1910 (Pl. V).

This variety is a promising one for planting in districts where climate renders the cultivation of the Persian walnut doubtful. It ought also to be of value for breeding in the Eastern States.

Chicoette.

Mayette type. Attention was first called to this variety by Mr. F. G. Peterson, head gardener at the Bidwell ranch at Chico, Cal., 1910. The tree was purchased among others and planted on the estate some years ago. E. M. Price writes of it as follows: "It is a prolific bearer; blossoms about the first of June and ripens its fruit in the early fall. It is a choice white-meated, well-flavored nut, resembling Mayette in form, and I am inclined to class it as a sport of the same."

Should this nut prove to be all that is described and be white meated under the extreme heat that frequently prevails in the region of Chico, it will be a valuable acquisition.

Cluster.

Type: Above medium to large; broadly oblong to oblong ovate; base rounded to obtuse; apex acute to acuminate, mucronate tipped; sutures appressed; flange narrow, very firmly sealed; shell bright yellow, generally smooth, though covered with a network of fine depressed veins, moderately thick. longitudinal lines well defined though not conspicuous; diaphragm strongly shouldered and quite persistent, though only of moderate thickness. *Origin*: Belgium; introduced into the United States by Felix Gillet; specimens grown upon a grafted tree by Mr. Gillet, crop of 1891 (Pl. VIII).

Mr. Gillet says, "The fruits of this variety are of average size and grow in clusters of 8 to 15." The distinctive form and general surface character of this nut are attractive. If upon further examination the quality should prove to rate high, it would be entitled to extended tests in the north Pacific coast region and in the more favorable sections of the Eastern States.

Columbus.

Mayette type. Originated with Felix Gillet from the nut of a second-generation Mayette. The nut is very large, exceedingly pretty, roundish, with smooth, light-colored shell, and kernel of first quality. Named "Columbus" in honor of the World's Fair at Chicago, 1893.¹

Common.

Synonym of Mission and of Fertile.

Concord.

Cluster type: above medium; oblong to roundish oblong; base rounded; apex rounded to obtuse, mucronate tipped; sutures appressed or very slightly ribbed, rarely pitted at the equator; flange moderate to narrow, firmly sealed; shell moderately thin, usually grayish brown, smooth, with few furrows and pits, longitudinal lines generally indistinct; diaphragm weakly shouldered but strong and occasionally persistent; kernel full, convolutions regular, even, moderate; pellicle of a brownish cast, rather

¹ Lelong, B. M. California Walnut Industry. 1895-96.

glossy, mildly astringent, veins inconspicuous; flesh crisp, slightly oily, rich; flavor sweet; quality fair to good. *Origin*: Chance seedling from an importation of Cluster nuts by Felix Gillet; first grown by J. M. Westcott, of Concord, Cal.; specimens grown by Ely I. Hutchinson, crop of 1910 (Pl. V).

A variety worthy of extended trial. The tree is a strong, robust grower, possessed of ample, large, smooth, light-green leaves. It yields under good care a crop somewhat above the average in quantity. The nut is of attractive form and size, though the color is a trifle gray for the connoisseur. It should be an excellent parent for breeding blight-immune and late frost-proof varieties. It is recommended for trial by the University of California as blight resistant.¹

Cosine.

A variety of no special merit, but of some historic interest as being the first Chilean seedling produced in Oregon.

Cumberland.

Parisienne type; medium to slightly above; roundish ovate; base obtuse to slightly rounded; apex obtuse to acute with mucronate point; sutures lightly ribbed or even somewhat appressed toward the base, pitted at the equator; flange narrow, firmly sealed; shell thin, but roughened with numerous irregular and variable depressions, central longitudinal lines usually well defined; diaphragm weak shouldered, thin, and rarely persistent; kernel full, plump, convolutions large, irregular, and variable; pellicle brownish yellow, dull, astringent; veins inconspicuous; flesh oily, rather rich; flavor sweet; quality fair. *Origin*: A nut brought from Germany in 1868 and planted in Carlisle, Pa., by Mrs. John Meek, produced the parent tree of this variety; specimens supplied by Miss Sarah E. Motts, crop of 1910 (Pls. VI and XI).

A variety that merits general trial throughout the walnut-growing areas of the Eastern States. It is distinctly in advance of the average seedling Persian walnut of this region.

Cutleaf.

Fertile type as to form; small, oblong to narrowly oblong; base rounded; apex obtuse to acute with mucronate tip or quite strong point; sutures slightly ribbed, pitted at the equator; flange broad, very firmly sealed; shell rather thick, smooth to slightly roughened by various furrows and occasional depressions, longitudinal lines distinct; diaphragm strongly shouldered and somewhat persistent; kernel full, plump; convolutions variable, though usually pronounced. *Origin*: Europe; specimens grown by the California Nursery Co., crop of 1891 (Pl. VIII).

This is a variety for the amateur, but of no promise for commerce. It is thus described by Felix Gillet; "The foliage of this variety is so delicate, so finely cut up, that it makes a most graceful ornamental tree, worthy to be planted conspicuously in the garden or front yard. The nut, besides, is exceedingly pretty, of fair size, round, with a very smooth shell and sweet kernel. The tree is claimed to be an abundant bearer."

Dean.

Sorrento type, modified; medium to above medium; oblong to broadly oblong and not infrequently more or less obovate; base obtuse to more or less acute; apex obtuse, or even retuse to occasionally acute, with mucronate tip or sometimes a quite strong point; sutures usually appressed, though occasionally moderately ribbed; equatorial pits usually present; flange

¹ Bulletin 203, California Agricultural Experiment Station.

² Lelong, B. M. California Walnut Industry. 1895-96.

moderately broad, firmly sealed; shell rather thick, quite smooth, even and usually regular, grayish brown, splotched; diaphragm rather weakly shouldered, but inclined to toughness and usually persistent; kernel full, plump, with even, regular, moderate convolutions; pellicle dark, rich, golden brown, dull, scarcely astringent; flesh very oily, only moderately sweet; flavor mild or indifferent; quality fair. *Origin*: The parent tree of this variety was produced from a nut purchased by O. Z. Dean from the local grocery store at Shellman, Ga., in 1878 or 1879, and planted where the tree now stands. The bole is 10 to 12 inches in diameter, the foliage heavy, and the tree has been bearing 15 or 20 years. Z. P. Dean states that the crop varies from 25 to 75 pounds; specimen by courtesy of Z. P. Dean, crop of 1911 (Pl. X).

Derby.

Lalande type modified; medium; oblong to broadly oblong, or sometimes even slightly obovate; base obtuse to occasionally almost acutely rounded; apex almost truncate to obtuse with short, strong point usually double-tipped; sutures appressed over lower half, moderately ribbed over upper half, irregularly pitted toward or above the equator; flange very broad and firmly sealed; shell thick, strong, grayish, moderately smooth, though strongly marked with veinings, longitudinal lines pronounced, not infrequently all six fully defined; diaphragm heavy shouldered, strong, and persistent; kernel full but not plump; convolutions moderate and variable; pellicle beautiful, rich, brownish yellow, dull, slightly astringent, veins scarcely noticeable; flesh crisp, fine grain, oily; flavor indifferent, moderately sweet; quality fair. *Origin*: A seedling with S. H. Derby, Woodside, Del.; specimens from Mr. Derby, crop of 1911 (Pl. IX).

Drew.

Chaberte type; small; rounded to more or less obovate; base rounded with projecting tip of extended sutures; apex obtuse to retuse-truncate, with mucronate tip; sutures moderately ribbed, usually somewhat pitted at the equator and toward the base; flange rather broad, very firmly sealed; shell rather thin, yellowish, somewhat roughened by numerous slight depressions, pits, and protuberances; longitudinal lines usually present and well defined; diaphragm thick, heavy, firmly shouldered, and persistent; kernel full with ample and variable convolutions; pellicle dull to semiglossy, light brown, scarcely or slightly astringent; veins inconspicuous or occasionally a few dark ones; flesh rather crisp, oily; flavor rather sweet; quality fair. *Origin*: Chance seedling from a nut planted by Andrew Corsa, Milford, Del., in 1875; specimens grown by W. P. Corsa, crop of 1894.

J. L. Budd, in the *American Horticultural Manual*, part 2, 1903, states that the kernel of this variety is thick, plump, and easily extracted, the meat yellowish, and the quality very good. It was disseminated to a small extent, particularly in Pennsylvania. The original tree was a shy bearer and after producing a few crops was cut down. Efforts to obtain data in Pennsylvania have failed to yield any definite information.

Dwarf Prolific.

Synonym of Fertile.

Ellwood.

Nave type; medium to above medium; narrowly oblong to elliptical; base obtuse to acute; apex acute, though sometimes obtuse, with strong point; sutures moderately ribbed, pits variable, usually clustered toward the base; flange usually medium, though variable, well sealed; shell thin,

bright yellow, moderately smooth, amply veined; longitudinal lines variable though usually present; diaphragm weakly shouldered, thin, and rarely persistent; kernel quite full though not plump, convolutions medium, variable, and broken; pellicle golden yellow to brownish, very mildly astringent, veins few, somewhat darker; flesh firm, crisp; flavor nutty, moderately sweet; quality fair. *Origin*: Chance seedling at the home of Ellwood Cooper, near Santa Barbara, Cal.; specimens from Mr. Cooper, crop of 1911 (Pl. XI).

Mr. Cooper looks with favor upon this type of nut, but the writer is of opinion that the elongated, elliptical, pecan-shaped walnut is not the best form for a permanent type of dessert nut.

Eureka.

Persian Long type; large, somewhat angular, rather narrowly oblong, lower half frequently tapering to base; base rounded or somewhat angular, acute, though occasionally somewhat obtuse; apex obtuse or acute, usually strongly pointed; sutures only moderately ribbed, rarely pitted at the equator; flange moderate or rather broad, very firmly sealed; shell rather thick, grayish (possibly due to bleaching), slightly roughened by irregular shallow depressions; longitudinal lines usually present and well defined; diaphragm rather firmly shouldered, thin, yielding, rarely persistent; kernel full, plump, convolutions moderate, variable, and broken; pellicle light yellow, glossy, astringent, veins usually inconspicuous; flesh rather coarse, rich, oily; flavor insipid; quality fair. *Origin*: A seedling on the Stone property, Fullerton, Cal., from a nut taken from the original Kaghazi trees on the Meak property at Haywards; first propagated by grafting in 1905; specimens grown by E. G. Ware, crop of 1910 (Pl. VII).

This variety is one of half a dozen recommended by the University of California for trial in the search for blight-immune varieties.¹ While not of high quality it may serve as parent to a variety of much greater merit if sufficiently blight resistant. The form of the nut is against it, at least for dessert purposes. Long, narrow, angular walnuts are not accepted upon the leading markets as desirable forms. The accredited form is the Grenoble, Mayette, or Parisienne, though the best grades of the Chinese would probably be equally acceptable. At the present time there is little discrimination by buyers against nuts on account of form, but as soon as the crop is produced to such an extent that markets are sought, form will become an important factor in determining the price. The Eureka is highly recommended by some leading growers of southern California as a very desirable variety, and promises to be one of the leaders in commercial plantings.

Specimens of this variety grown by Dr. W. W. Fitzgerald, of Stockton, Cal., crop of 1911, rate considerably higher in quality than those examined and described in 1910. Of the latter it may be said that the flavor is mild and sweet and the quality good, while all other essential features answer the description.

Favorite.

Approaching Franquette type; above medium to large; usually oblong though frequently unilateral, while smaller ones are sometimes rounded; base obtuse, rounded, and frequently oblique; apex obtuse with short and rather stout mucronate tip; sutures usually quite strongly ribbed, equatorial pits negligible, though pits are generally present along the surface, especially along the lower half; flange very broad and very firmly sealed;

¹ Bulletin 203, California Agricultural Experiment Station.

trees each year; (4) to incur the increased cost of grafted trees over that of nuts and seedling trees was not advisable under the circumstances; (5) the small loss occasioned by planting some seedling trees of indifferent value would be counterbalanced by the difference in cost and the increased value of the property due to immediate planting, which could be done with either nuts or seedling trees, as there were plenty of these upon the market. Whether results will confirm these views remains to be seen with the fruiting of the tracts. The eagerness of planters to set out walnuts at that time was no doubt instrumental in causing one or two points of moment to be overlooked, namely, that grafted trees usually fruit earlier than seedlings, and that the stock is an important factor which is entirely ignored in the planting of seedlings. At the same time insufficient weight is accorded the fact that seedling trees yield at best a variable product which is not true to name. With whatever variety or section concerned, the day of making a walnut orchard with nuts or seedling trees is past. Hereafter, not alone type or variety but stock and scion as well must be given full consideration, and this necessarily implies grafted or budded trees.

While the form of Franquette is not as acceptable to connoisseurs as that of Mayette, the uniform size, rich golden-yellow color, and peculiar rustic appearance, together with the mild-flavored fat kernel, will do much to make it a popular variety. Especially does this statement apply to the Oregon-grown Franquette, which is generally conceded to be somewhat sweeter than other American-grown specimens of this variety. The one serious fault of the Franquette is that the trees yield to the attack of the blight in several districts, though it is recommended for trial by the University of California.¹

Garden Grove Prolific.

Synonym of Prolific.

Geit.

Parisienne type; above medium to large; roundish oblong; base obtuse to obliquely truncate; apex rounded with mucronate tip; sutures appressed over lower half, slightly to moderately ribbed over upper half, usually one or two pronounced pits at the equator; flange broad, very firmly sealed; shell thick, hard, moderately to quite smooth, longitudinal lines rarely defined; diaphragm strongly shouldered and persistent; kernel quite full, convolutions variable, broken, uneven; pellicle dark brown, astringent, semiglossy, veins inconspicuous; flesh rather crisp, rich, oily; flavor indifferent; quality fair. *Origin:* A seedling tree in Lancaster County, Pa.; first brought to public attention at the Northern Nut Growers' Convention, Ithaca, N. Y., December, 1911, by J. G. Rush.

For planting in the eastern United States this variety is not comparable with Cumberland, Holden, Mount, Nebo, Pomeroy, or Rush.

Glad.

Bijon type; very large; oblong, angular, sometimes tapering to the base; base rounded though occasionally truncate; apex obtuse or slightly acute with mucronate tip; sutures appressed, more or less depressed toward the base; flange usually narrow and firmly sealed; shell moderately thick, brownish yellow, very rough, and strongly marked with veins; diaphragm rather thick, though not strongly shouldered, usually persistent; kernel not full, somewhat shriveled, convolutions moderate and rather regular;

¹ Bulletin 203, California Agricultural Experiment Station.

pellicle light, glossy, very astringent; veins dark and conspicuous, though not numerous; flesh dry, tough; flavor mild, moderately sweet; quality fair. Specimens grown by Ferd Groner; crop of 1910 (Pl. XI).

Grand Noblesse.

Round Mayette type; above medium to large; roundish oblong to somewhat obovate; base obtuse truncate; apex obtuse with mucronate tip; sutures appressed to slightly ribbed; pits at the equator present and pronounced or absent; flange varying from moderate to broad and quite firmly sealed; shell rather thin, usually smooth, yellowish, longitudinal lines generally present and quite well defined. *Origin:* California; reported by L. L. Bequette, of Rivera, Cal., but practically unknown in that section, as it proved of little value; crop of 1890.

Grenoble.

A term loosely used to designate the French-grown Mayette or to include the three leading varieties in the Grenoble district of France, viz, Mayette, Franquette, Parisienne. The nut shown in Plate IV, called Grenoble by the growers, T. B. Bishop Co., is really a form of Santa Barbara and not one of the three varieties here named.

Hales.

Persian Long type, modified; above medium to large; rather narrowly oblong; base obtuse to almost truncate, some specimens will stand obliquely on end; apex obtuse, usually more or less refuse, resulting from prominent shoulders, strong mucronate tip; sutures strongly ribbed, with deep, broad, and variable pits at the equator; flange very broad, strongly sealed; shell thin, moderately yellowish, fairly smooth except along sutures, amply veined and somewhat marked by small, deep pits, longitudinal lines very much broken, though not infrequently well defined but shallow and narrow; diaphragm weak shouldered, thin, and rarely persistent; kernel of shrunken appearance though filling the shell, convolutions strongly pronounced and variable; pellicle brownish, very slightly astringent; veins ample, well defined, and darker brown; flesh firm, crisp, only moderately oily; flavor very sweet, mild, pleasant; quality very good. *Origin:* Original tree grew on the property of W. L. Hale, Fullerton, Cal; specimens grown by J. B. Neff; crop of 1911 (Pl. IX).

Though this variety has not been given general trial, a few leading growers are testing it, and the following report is by J. B. Neff: "It is showing fairly well in blight-resistant qualities—in fact, better than any other variety that I have—but while the nuts are large and fine, it does not produce as large crops as some others."

Hall.

Bljoun type; very large; oblong angular, usually tapering to the base; base rounded with the sutures but obtuse at right angles; apex obtuse to slightly acute, with rather strong blunt point; sutures appressed or very slightly ribbed, deeply and broadly pitted at the equator; flange broad, very firmly sealed; shell rather thick, brown with broad patches of yellowish gray-brown, very rough with irregular convolutions, pits and depressions, longitudinal lines rarely marked; diaphragm firmly shouldered and usually persistent; kernel shrunken, convolutions very variable and broken; pellicle yellowish, astringent, veining inconspicuous; flesh firm, rather dry; flavor mild; quality fair. *Origin:* Chance seedling in Germany transplanted at the age of 1 year to a place near Avonia, Pa.; specimens supplied by L. C. Hall, crop of 1910 (Pl. III).

Hays.

Brantome type; medium; oblong, inclined to angularity; base obtuse to truncate, nearly half will stand erect; apex obtuse, occasionally retuse or acute, scarcely mucronate; sutures appressed toward the base, moderately ribbed at center and toward apex, pits at the equator variable; flange narrow to medium, fairly well sealed; shell thin, yellowish brown to brownish, roughened with irregular depressions and protuberances, longitudinal lines rarely defined; diaphragm strongly shouldered and inclined to be persistent; kernel quite full, moderately plump, convolutions moderate, variable, and broken; pellicle yellowish brown, glossy, astringent, veins few, darker brown; flesh crisp, grain fine, oily; flavor and quality not determinable, through age of specimens. *Origin*: A seedling on the property of Amos H. Hays, Parkton, Md., and named by H. E. Van Deman about 1904; specimens grown by Mr. Hays, crop of 1908 (Pl. IX).

Hightstown.¹

Medium, long, ovate; shell fairly thin; kernel plump and good. A variety grown and propagated at Hightstown, N. J.; hardy and fruitful when planted in groups, as, like the chestnut, isolated trees rarely bear nuts.

Hindes Perfection.

Synonym of Placentia.

Hindes Perfection Placentia.

Synonym of Placentia.

Hindes Placentia.

Synonym of Placentia.

Holden.

Marbot type; above medium; oblong to narrowly oblong; base rounded, occasionally obtuse; apex rounded or obtuse, mucronate sutures moderately to strongly ribbed, scarcely pitted at the equator; flange broad, firmly sealed; shell grayish yellow to light yellow, moderately smooth, scattered shallow depressions, longitudinal lines usually inconspicuous; diaphragm strong and firmly shouldered; kernel quite full, convolutions moderate; pellicle light ground with darker tinge, semiglossy, astringent, veining indifferent but dark; flesh oily, rich; flavor sweet; quality good. *Origin*: Chance seedling on the property of E. B. Holden, Hilton, N. Y.; specimens grown by Mr. Holden, crop of 1910 (Pl. VII).

Honeydew.

Mayette type; large, oblong; loose, obliquely obtuse; apex obtuse with strong point; sutures rather strongly ribbed at the equator, but appressed toward the base, where abrupt enlargements along the sutures characterize the form of the nut; usually strongly pitted at the equator; shell rich yellow, rather rough from irregular basal protuberances and deep irregular depressions along pronounced sutures and longitudinal lines. *Origin*: Obtained by F. A. Leib from scions imported from France; a decided improvement in appearance over the usual Mayette obtained in a similar manner; specimen grown by Mr. Leib as first crop, 1910 (Pl. III).

Hubbard.

Sorrento type; above medium; oblong; base rounded; apex acute, with rather strong point; sutures slightly ribbed at the equator, appressed at both ends, especially at the base, usually pitted at the equator; flange very firmly sealed; shell grayish brown, quite smooth, though longitudinal lines are more or less well defined. *Origin*: California; specimens supplied by E. M. Price, crop of 1910 (Pl. VIII).

¹ J. L. Budd, in the American Horticultural Manual, pt. 2, 1903.

To the planter who fancies this type of nut, by some called pecan-walnut and known in the market as the Italian walnut, the Hubbard promises to fulfill the demand for appearance. It is to be propagated by budding, and data to determine its value will soon be available.

Ignotum.

A name applied to a variety obtained from crossing *Juglans regia* with *Juglans cinerea*. Both tree and nut of botanical interest only.

Jauge.

Synonym of Mammoth.

Journey.

Santa Barbara type; large; broadly oblong, or occasionally obovate and angular; base obtuse, or even obliquely truncate; apex obtuse, with strong point; sutures strongly ribbed, usually pitted at the equator; flange very firmly sealed; shell grayish yellow, roughened by numerous and often deep pits and irregular depressions; longitudinal lines rarely evident. *Origin*: Chance seedling from a Chilean nut planted in California; specimens supplied by E. M. Price, crop of 1910 (Pl. VIII).

Juglans monoheterophylla.

Synonym of *Juglans regia monophylla*. On the grounds of the Department of Agriculture at Washington is a tree of this very interesting variety marked under the synonym. As the specific name implies, the leaves are simple and variable. Those at the base of the shoots are usually broadly ovate with cordate bases, while those above vary from broadly oblong-lanceolate to narrowly lanceolate. The original tree, long since destroyed, was first observed as a chance seedling at St. Foy, near Dieppe, France, in 1833. In 1865 Carrière records (*Revue Horticole*, p. 130) that only two trees directly produced from the original were then in existence. The tree in Washington is small, with numerous slender branches, and is chiefly interesting on account of its remarkable foliage. The fruit is said to be of indifferent quality. Of botanical interest only.

Juglans racemosa.

Synonym of Cluster. Of this species the late Felix Gillet said: "It is a fact that the nuts are borne in clusters; aside from this character, the tree, foliage, and fruit resemble, or are even identical with, *Juglans regia*."

Juglans regia laciniata.

Synonym of Cutleaf.

Juglans regia pendula.

A specimen tree on the grounds of the United States Department of Agriculture is of moderate vigor, hardy, sprawling, somewhat pendulous, with leaves of medium size. The writer has had no opportunity to examine the fruit. A few nuts set in 1911 were probably taken before maturity by squirrels. If this authentic specimen of *Juglans regia pendula* is a fair sample, hundreds of the younger trees in California, notably in the Vrooman orchard, afford a far greater display of long, slender, pendulous branches. These are pruned each year, so that there are no examples of the kind of tree such growths would ultimately produce.

Kaghazi.

Persian Long type; above medium to large; oblong, occasionally roundish and angular, lower half usually narrowed; base rounded; apex acute or obtuse on the rounded specimens, usually with strong point; sutures moderately ribbed, more or less pitted at the equator; flange variable, firmly sealed; shell grayish brown to yellowish, rather rough, with irregular depressions, longitudinal lines more or less distinct as pitted furrows; dia-

phragm firmly shouldered, strong and frequently persistent; kernel full, convolutions small, irregular, and separate; pellicle light brown, glossy, astringent; veining distinct though sparse; flesh rather coarse, oily, rich; flavor sweet; quality good. *Origin:* Nuts obtained through the American consul in Persia were planted by Mr. Meak, of Haywards, Cal., and from these were produced two trees, the nuts of which were deemed especially meritorious. To these trees was given the name Kaghazi. The nuts of both trees have been used for propagation, and in consequence more or less variation exists in the type of nut, but probably no more than would be the case from any seedling trees. Specimens grown by A. L. Linquist, crop of 1910 (Pl. VI).

The trees of this variety grown near Goleta, Cal., have not been attacked by blight and are considered by Mr. Linquist and others to be blight resistant, if not altogether immune. The test will not be complete until blight has attacked in this same orchard other varieties susceptible elsewhere. Should the Kaghazi then remain free from injury, its resistance will be beyond question.

Keesling.

Persian Long type, modified; above medium to large; elliptic usually, though not infrequently oblong or occasionally almost obovate; base obtuse or rounded; apex obtuse, rounded, or even acute and usually with a strongly mucronate tip; sutures appressed to slightly ribbed, equatorial pits not pronounced and often not present; flange broad, fairly well sealed; shell rather thick, yellow, but frequently with an indifferent grayish overcast, quite regular, rather smooth, though an occasional nut is rough, with deep pits, broken lines, and furrows, longitudinal lines usually distinct; diaphragm weakly shouldered, thin, and very rarely persistent; kernel full, plump, convolutions moderate, irregular, and variable; pellicle dull to semi-glossy pale brownish, quite astringent; veins few, inconspicuous; flesh crisp, oily; flavor mildly nutty; quality fair to good. *Origin:* A seedling on the property of Horace G. Keesling, San Jose, Cal., from nuts planted in 1879; specimens from grafted trees on Mr. Keesling's property, crop of 1911 (Pl. IX).

The tree is reputed to be prolific and regular. On the whole the variety appears to be worthy of trial. We are not informed as to its resistance to blight.

Klondike.

Bijou type; very large; oblong to obovate; base rounded or even long tapered; apex rounded to obtuse, mucronate; sutures appressed, usually pitted at the equator; flange narrow, many nuts imperfectly sealed; shell thick, grayish brown to yellowish brown, rough, with numerous irregular depressions and broken furrows, or quite smooth; longitudinal lines more or less distinct; diaphragm weak shouldered, though strong and frequently persistent; kernel not full, convolutions irregular, uneven, and moderate; pellicle brown tinged, mildly astringent, dull; veining generally distinct and dark; flesh coarse, rather dry; flavor sweet; quality fair. *Origin:* During the decade 1880-1890 Mr. T. L. Gooch, of Rivera, Cal., obtained specimens of nuts imported by a San Francisco firm, and from these planted by Mr. Gooch and a neighbor, Jacob Ott, to whom he had given a few, were produced two trees yielding nuts of large size and unusual shape, named Klondike by the attendants at the local packing house; specimens grown by A. L. Linquist, crop of 1910 (Pl. III).

Laciniated.

Synonym of Cutleaf.

Lane.

Santa Barbara type; above medium to large; roundish to broadly oblong; base obtuse to almost acute; apex usually acute with strong point, though sometimes rounded; sutures moderately ribbed nearly the whole length on one side while appressed near the base on the other, equatorial pits variable, sometimes wholly absent; flange usually narrow, scarcely medium, rather weakly sealed; shell thin, occasionally very thin, yellowish, smooth; well-defined longitudinal lines infrequent; diaphragm weakly shouldered, scarcely persistent; kernel full, plump, convolutions moderate, fairly regular; pellicle yellowish tinged with brown, dull, mildly astringent; veins inconspicuous; flesh crisp, medium grain, oily; flavor mild, sweet, pleasant; quality good. *Origin*: Seedling originating in Santa Barbara County, Cal., on the ranch of W. H. Johnson; specimens from grafted trees on the property of Miles P. Lane, crop of 1911 (Pl. IX).

C. W. Beers, horticultural commissioner for Santa Barbara County, Cal., says "the Lane tree produces a large, smooth nut of good quality. The tree is vigorous, assumes a desirable form, and bears an abundance of fruit spurs, even to the main body. The nuts mature so nearly at the same time that the whole crop can be successfully harvested at one picking. In 1910 and 1911 the pickings were made before the last gathering of the regular Santa Barbara in the same orchard. Growing amidst trees that lost 80 per cent of their crop by blight in 1910, this tree has shown no effects of the disease, though other trees in the same orchard have been affected. The parent tree also thus far has been exempt from this trouble."

Lanfray.

Type; large-fruited variety catalogued by Felix Gillet, but not yet reported as fruiting in the United States. H. M. Williamson, Report of Oregon Board of Horticulture, 1906, says, "It is a nut of most attractive appearance and is very heavy in proportion to size, as it is so well filled with meat."

Large Fruited.

Synonym of Bijou.

Large-Pointed Præparturiens.

Ascribed to Felix Gillet in Bulletin 92, Oregon Agricultural Experiment Station.

Late.

Synonym of Serotina.

Late Fertile.

Fertile type, small; broadly oblong to obovate; base rounded, obtuse, or occasionally truncate; apex obtuse, mucronate; sutures, strongly ribbed; broad pits at the equator usually present; flange narrow, very firmly sealed; shell yellowish, somewhat roughened, rather thick, longitudinal lines not conspicuous though generally present. *Origin*: Chance seedling at Barren Hill Nurseries; specimen grown by Felix Gillet; second generation, crop of 1891 (Pl. VIII).

Mr. Gillet said of this variety: "It is late in vegetating and hence hardy; kernel is full fleshed and very sweet."

Late Præparturiens.

Synonym of Late Fertile.

Lea.

Montignac type; medium to small; roundish, angular, occasionally tapered toward apex; base obtuse truncate, many specimens will stand erect; apex obtusely rounded, scarcely any tip; sutures slightly to broadly ribbed over upper half, appressed below; variously pitted at the equator. pits usually indifferent; flange very narrow, firmly sealed; shell very thin. grayish brown to yellowish, moderately smooth, longitudinal lines rarely well defined; diaphragm strongly shouldered, strong, and persistent; kernel full, plump, convolutions moderate, broken, variable; pellicle brownish, dull to semiglossy, very mildly astringent; veins inconspicuous; flesh crisp, starchy, moderately oily; flavor mild, sweet; quality fair. *Origin*: Wilmington, Del., about 20 years ago. It is a seedling from another tree, also a seedling, planted in the locality about 40 years ago. It began bearing at 8 or 9 years of age and has borne yearly since. Owing to the thin shell of the nut, blackbirds do considerable damage to the crop. It is in excellent repute for pickling, being superior in flavor to other varieties used for this purpose. Specimens grown by Miss Lea, Wilmington, Del., crop of 1911 (Pl. IX).

Longbeaked.

A variety catalogued by the Georgia Horticultural Society in its report for 1900. Probably a synonym for Serotina.

Los Angeles.

Synonym of Mission.

Mammoth.

Bljou type; an immense nut, the largest yet originated. So large are the shells of some that "ladies' companions," wherein to stow away gloves and handkerchiefs, are made from such shells by fancy-goods manufacturers. The nut though of such large dimensions has a thin shell and the kernel is of first quality.¹

Mammoth Fertile.

A large-fruited variety of the Fertile that originated in France. The nut is extraordinarily large; soft shell; full-fleshed kernel.¹

Mayette.

Type, Kerr form; large; ovate, rarely oblong; base obtuse; apex obtuse to slightly acute with mucronate tip; sutures appressed to slightly ribbed, pitted at the equator; flange narrow, very firmly sealed; shell thin, grayish yellow, quite smooth except along the sutures, longitudinal lines quite distinct; diaphragm usually weakly shouldered, thin, and rarely persistent; kernel full, only moderately plump, convolutions pronounced, somewhat irregular, pellicle grayish yellow, glossy, very slightly astringent; veins sparse, but usually well defined by their darker color; flesh oily, rich; flavor sweet; quality very good. *Origin*: France; specimens grown by Tribble Bros., crop of 1910 (Pl. V).

Mayette Blanche.

A Mayette having a light-colored or whitish flesh.

Mayette Longue, Mayette Ronde, and Mayette Rouge.

A Mayette having reddish-colored flesh.

Type forms recognized as authentic in France, but not yet distinguished by American growers or in the American market.

¹ Lelong, B. M. California Walnut Industry. 1895-96.

Mayette Seedling.

A "second-generation" Mayette, grown by George C. Payne, Campbell, Cal., differs from the Kerr type in that the nut is more ovate, the upper half more tapering, and apex more acute; the shell is a rich yellow, the sutures not quite so firmly sealed, and the flavor better.

A type of Mayette grown by Thomas Prince, Dundee, Oreg., conforms very closely to the Payne "second generation" type in both color and form, though there is a larger percentage of oblong specimens; they have a reddish tone added to the rich yellow of the Payne Mayette; they are perceptibly smaller, though very uniform, with a kernel that is sweeter and less oily.

A seedling Mayette grown by Ely I. Hutchinson, Concord, Cal., conforms in color and form very closely to the Kerr type, though somewhat smaller, with a rather sweeter and more oily kernel.

A seedling Mayette grown by E. Terpenning, Eugene, Oreg., is medium in size, very sweet, and firmly sealed. The tree is reputed to be a regular and heavy bearer.

Mayquette.

Franquette type; above medium to large; oblong, with upper half tapered and somewhat angular; base obtuse to slightly rounded; apex acute or occasionally obtuse, with rather strong point; sutures strongly ribbed, pitted at the equator; flange broad, very firmly sealed; shell rather thick, roughened with irregular protuberances and irregular variable depressions and pits and a few deep-seated veins, longitudinal lines usually well defined; diaphragm strongly shouldered, thin but usually persistent; kernel full, plump, convolutions pronounced and broken; pellicle brownish tinged, glossy, slightly astringent; veins inconspicuous; flesh crisp, oily, starchy; flavor moderately sweet, pleasant, mild; quality fair to good. *Origin:* A seedling from artificial pollination of Franquette $\times$ Mayette by Tribble Bros., Elk Grove, Cal.; specimens from the above firm, crop of 1910 (Pls. VI and X).

Mesange.

Modified Franquette type; small, oblong to oblong ovate; base obtuse, rarely truncate; apex acute with strong point; sutures somewhat appressed toward the base, moderately to strongly ribbed above, slight pits usually present at the equator; flange narrow, very firmly sealed; shell yellowish or grayish yellow, thin, more or less roughened by slight irregular depressions; variable furrows and small protuberances; longitudinal lines commonly present and well defined. *Origin:* Europe; specimens grown by Felix Gillet; second generation, crop of 1891. Introduced by Mr. Gillet. Elicited from the importer the following comment after its first fruiting in this country: "It is so named from the fact that the shell is so thin that the titlark, though a little bird, can pierce it and thus feed upon the kernel. The tree is very productive, while the nut is excellent for dessert and pickling, and is quite rich in oil."

Meylan.

Type; above medium; ovate or broadly oblong; base truncate; apex obtuse or acute, mucronate; sutures appressed to slightly ribbed, slight depressions, rarely a small pit at the equator; flange narrow to moderate, very firmly sealed; shell thin, rich yellow, smooth and regular, longitudinal lines frequently well defined; diaphragm firmly shouldered, thin and yielding; kernel full, moderately plump, convolutions moderate, irregular; pellicle

light yellowish, glossy or dull, very slightly astringent, veins sometimes abundant, giving the kernel a brownish cast; flesh very oily, rich: flavor sweet, pleasant; quality best. *Origin*: Europe; specimens grown by Ely I. Hutchinson, crop of 1910 (Pl. III).

A type of Meylan grown by Mr. Prince is somewhat smaller and darker with veins of the shell more conspicuous, kernel somewhat darker and not so plump though sweeter and less oily.

Milbank.

Parisienne type; above medium; oblong; base obliquely obtuse to obliquely truncate, about half will stand nearly erect upon base; apex obtuse, often more or less oblique, and apparently depressed as result of prominent shoulders, tip varies from practically none to an occasional rounded one of some strength; sutures with basal half appressed, apical half more or less ribbed, equatorial pits less pronounced than in the type but usually present at least on one side, occasionally quite deep depressions near the base; flange broad, usually firmly sealed though not difficult of separation; shell moderately thin, of pleasing yellowish color, moderately smooth, though well marked with shallow veining, longitudinal lines distinct though often irregular and broken; diaphragm strongly shouldered at basal end in particular and usually persistent; kernel full, convolutions rather strong and variable though moderately smooth, veins indistinct; pellicle light glossy to semi-glossy, mildly astringent; flesh tender, crisp, moderately rich; flavor mild, rather sweet and pleasant; quality good. *Origin*: A seedling planted on the property of the late Mrs. Jeriamah Milbank, in Connecticut, about 1876; specimens from the original tree, crop of 1911 (Pl. IX).

While the tree is not a heavy bearer, it produces a good average annual crop and is said to be a robust, vigorous grower.

Mission.

Type; medium; oblong or obovate and somewhat angular; base obtuse to rounded; apex obtuse with mucronate tip or strong point; sutures from slightly to strongly ribbed, indifferently pitted at the equator; flange usually broad, firmly sealed; shell grayish brown, thickened by numerous irregular protuberances and roughened by pits and depressions, longitudinal lines occasionally well defined. *Origin*: California; specimens grown by Charles S. Wilcoxon, crop of 1891.

This variety was planted by the Spanish padres about the early missions in California. It is not now of commercial importance nor of varietal consequence. It is also known as Santa Barbara Hardshell.

Mobart.

Merely listed and illustrated by Lelong in his treatise entitled "California Walnut Industry."

Mount.

Marbot type; medium; oblong, somewhat angular and occasionally tapering to the base; base rounded to acute; apex obtuse, infrequently truncate, mucronate; sutures quite strongly ribbed, sometimes pitted at the equator, but usually merely slight depressions; flange moderate, very firmly sealed; shell rather thick, bright yellow, moderately smooth, longitudinal lines usually present and well defined though sometimes variously broken; diaphragm rather thick, firmly shouldered, frequently persistent; kernel quite full, fairly plump, convolutions moderate, irregular and broken; pellicle reddish, dull, astringent; veins inconspicuous; flesh somewhat coarse, oily; flavor indifferent; quality fair. *Origin*: Original tree is growing upon the property of Joseph S. Mount, Hamilton Square, N. J.; was planted as a

small tree in 1884 and has borne more or less of a crop since 1890, when it produced its first fruit; specimens grown by Mr. Mount, crop of 1909 (Pl. VIII).

Nebo.

Parisienné type; large; broadly oblong to oblong ovate; base obtusely rounded; apex retuse with very slight mucronate point; sutures strongly ribbed above but depressed below and distinctly pitted at the equator. *Origin*: Chance seedling in Lancaster County, Pa.; specimens supplied by J. G. Rush, crop of 1910 (Pl. V).

Neff.

Santa Barbara type; large; roundish oblong, occasionally tapering toward the base, quite angular and irregular; base rounded and usually with one lobe projecting; apex obtuse with strong point; sutures quite strongly ribbed, occasionally pitted at the equator; flange broad, only moderately sealed; shell rather thick, grayish yellow, roughened with numerous depressions, largely due to strong veining and slight rounded protuberances, longitudinal lines quite well defined though usually broken; diaphragm strongly shouldered but thin and yielding, scarcely persistent; kernel moderately full and plump, convolutions usually slight though variable and broken; pellicle with a decided brownish tinge, glossy, mildly astringent; veins dark and well defined; flesh rather crisp, oily; flavor sweet, mild, pleasant; quality good. *Origin*: A tree obtained from a local nursery dealing in seedling stock planted among other trees from the same nursery at the same time—1892—by J. B. Neff, Anaheim, Cal.; Mr. Neff reports it to be the most prolific and regular bearer that he has. He also says: "It is not the smooth nut that I would like." Specimens grown by Mr. Neff, crop of 1910 (Pl. V).

Neff Prolific.

Synonym of Neff.

Norman.

Synonym of Pomeroy.

Papershell.

Synonym of Mesange. The term "Papershell" is also used for a variety with a very thin shell, formerly planted in California, but discarded as wholly unfit for the commercial orchard because the tree is a shy bearer, though the nut is of high quality.

Paradox.

A name first used by Luther Burbank in 1897-98 to designate a tree from a nut produced by a cross-fertilization of *Juglans regia* and *J. californica*. The term is now used to distinguish any tree arising from the cross-fertilization of these two species (Pl. II).

Parisienné.

Type; above medium to large; oblong, upper half often tapers to such extent that it has the appearance of being ovate; base obliquely obtuse; apex usually obtuse, though occasionally rounded with mucronate tip; sutures appressed to slightly ribbed, usually deep pitted at the equator, which is often below a median line; flange narrow to moderately broad, firmly sealed; shell thin, brownish, roughened with numerous irregular and shallow pits, longitudinal lines variable, usually indistinct; diaphragm weakly shouldered, thin but strong; kernel full, convolutions moderate, regular, and rather smooth; pellicle light, glossy, mildly astringent; flesh tender, oily, rich; flavor sweet; quality very good. *Origin*: Southeastern France nearly 200 years ago. Now rated by the French as one of the three highest quality dessert nuts. Specimens grown by George C. Payne; crop of 1911 (Pl. V).

Parry.

Illustrated in American Fruit and Nut Journal, June, 1908; also in Bulletin 92, Oregon Agricultural Experiment Station, in which publication it is said to be of medium size and rather flat at the base.

Payne.

Franquette type; above medium; oblong with upper half narrowed, or even almost tapering to the apex; base obtuse to rounded; apex sometimes rounded, usually acute with a strong point; sutures strongly ribbed, only moderately or not at all pitted at the equator; flange moderate and variable, firmly sealed; shell moderately thin, yellowish, rather smooth, though usually more or less furrowed and pitted with shallow depressions; diaphragm firmly shouldered but thin and weak; kernel full, convolutions even and moderate; pellicle light to slightly tinged with brown, very slightly astringent, veining slightly dark, though not pronounced; flesh rather dry; flavor mild, hardly sweet; quality fair. *Origin:* Accidental seedling discovered at Campbell, Cal., by George C. Payne, about 1898; parentage unknown, but of Franquette type. Specimens grown by Mr. Payne; crop of 1910 (Pl. VII).

Of this nut an Oregon grower, Mr. Ferd Groner, says: "It is a fine nut, but the blight affects it seriously. It is not adapted to Oregon conditions because it blossoms too early."

Payou.

Bijou type; very large; oblong, usually somewhat angular and narrowed at the base; base rounded; apex obtuse, mucronate; sutures appressed or slightly ribbed, narrowly and deeply pitted at the equator, which usually lies above a median line; flange narrow, imperfectly sealed; shell moderately thin, yellowish brown to darker, very rough with irregular convolutions and numerous depressions, longitudinal lines frequently evidenced by a series of narrow, deep pits; diaphragm firmly shouldered but thin and weak; kernel quite full, convolutions regular and large; pellicle rather dark, glossy, slightly astringent, veining quite pronounced and dark; flesh oily, rich; flavor sweet; quality very good. *Origin:* Offspring of a cross between Bijou and Payne made by George C. Payne in 1903 or 1904; specimens grown by G. C. Payne, the originator; crop of 1910 (Pl. III).

Pear Shape.

Synonym of Vilmorin.

Peerless (Papershell).

Bijou type. Originated with Mrs. Rebecca E. Semple, Burlington, N. J., from a nut planted by her in 1893. Reported as promising for Maryland in Bulletin 125, Maryland Agricultural Experiment Station. Considering the type to which the name "Papershell" has been applied in the past, the term is a positive misnomer.

Persian.

Type; medium; roundish oblong; base obliquely obtuse to rounded; apex obtuse to acute with mucronate tip; sutures moderately to quite strongly ribbed, irregularly pitted at the equator; flange moderate, very firmly sealed; shell thin, grayish yellow, rather thick, strong, moderately rough with numerous depressions and a few protuberances, longitudinal lines indistinct; diaphragm weakly shouldered, thin, scarcely persistent; kernel full, plump, convolutions large and variable; pellicle light yellowish brown, glossy, scarcely astringent, veins not conspicuous; flesh crisp, slightly oily; flavor very sweet, mild; quality good. *Origin:* Imported from France; specimens grown by Ely I. Hutchinson; crop of 1910 (Pl. IV).

Though Persian is a generic commercial term in general use, it is used in this case by Mr. Hutchinson and some others to designate a particular type of nut of medium size that has made a record for productiveness, while at the same time possessing considerable merit as a nut of high quality. It can hardly be classed as a "soft-shell" in the strict meaning of the term.

Persian Dwarf Prolific.

Synonym of Fertile.

Persian (round).

Nuts of the crop of 1911 were imported by the Office of Foreign Seed and Plant Introduction, Bureau of Plant Industry.

Placentia.

Santa Barbara type; large, decidedly angular; obovate to oblong; base rounded; apex obtuse to rounded, mucronate; sutures decidedly appressed, small, deep pits, few to none at the equator; flange narrow, firmly sealed, though a considerable number of specimens are imperfectly closed at apex; shell thin, dark brown, mottled with gray, rough with numerous pits of various sizes and broken ribs, longitudinal lines negligible; diaphragm variable, though usually more or less persistent; kernel full size though not plump, convolutions variable and irregular; pellicle light yellowish brown, more or less glossy, slightly astringent, veins few but sometimes quite pronounced by their dark color; flesh moderately oily; flavor sweet; quality good. *Origin:* Chance seedling about 1890 in Orange County, Cal.; specimens grown by J. B. Neff; crop of 1910 (Pls. VI and XI).

Placentia Perfection.

Synonym of Placentia.

Pomeroy.

Small; oblong; base rounded; apex rounded, occasionally slightly pointed, usually mucronate; sutures appressed or occasionally very slightly ribbed, scarcely pitted at the equator; flange broad, firmly sealed; shell smooth, thick, grayish brown to light yellowish, longitudinal lines inconspicuous; diaphragm strong, firmly shouldered, persistent; kernel full, convolutions moderate; pellicle light yellowish, astringent, veining generally inconspicuous; flesh moderately oily; flavor very sweet; quality good. *Origin:* With the late Norman Pomeroy, Lockport, N. Y., from nuts obtained by him from a tree in Philadelphia, and planted in 1876; specimens grown by Mr. Pomeroy, crop of 1910¹ (Pl. X).

Poorman.

Listed by Lelong, in "California Walnut Industry," as a variety of recent introduction.

Precocious.

Synonym of Fertile.

Prince.

Persian Long type; large; oblong to narrowly oblong, tapering to apex; base rounded; apex acute, occasionally obtuse, mucronate pointed; sutures appressed, moderately or not at all pitted at the equator; flange variable, usually narrow, not quite firmly sealed; shell dark brown, very conspicuously marked with narrow and slightly depressed veins producing the appearance of roughness while in truth it is quite smooth and even, longitudinal lines variable; diaphragm usually firmly shouldered, thin but strong and at times persistent; kernel not quite full, rather irregular, convolutions variable, generally only moderate; pellicle light yellow to brownish, glossy, mildly astringent; flesh moderately oily; flavor sweet, rich;

quality good. *Origin*: Chance seedling with the late Felix Gillet, California, about 1895; specimens grown by Mr. Prince, crop of 1910 (Pls. VII and XI).

Sold with others to fill an order for trees supplied to Thomas Prince, Dundee, Oreg. Its distinct form, size, and color so easily distinguished it from the other nuts in the orchard that it was given the above name after fruiting a few times. Unfortunately, it is not blight resistant at its home.

Prince of Yamhill.

Synonym of Prince.

Prolific.

Persian Long type; large; oblong to obovate; base rounded; apex usually acute with point obtuse or mucronate; sutures moderately or even strongly ribbed, rarely pitted at the equator; flange usually broad, firmly sealed; shell thin, grayish brown, roughened with numerous irregular and frequently rather deep pits and depressions, longitudinal lines usually present and well defined; diaphragm almost weakly shouldered, thin and yielding, rarely persistent; kernel full, plump, convolutions moderate and quite regular; pellicle rather dark (probably due to climate), glossy, astringent; flesh rather rich, very oily; flavor sweet; quality good. *Origin*: Chance seedling with E. G. Ware, Garden Grove, Cal., from a Santa Barbara nut obtained from the Sexton place; first propagated by grafting in 1899; well worth extended trial; specimens grown by Mr. Ware, crop of 1910 (Pl. VII).

Præparturiens or Præparturiens.

Synonym of Fertile.

Rivera Hardshell and Rivera Softshell.

Listed and illustrated by Lelong in his treatise entitled "California Walnut Industry."

Royal.

A name first used by Luther Burbank in 1897-98 for a tree from a nut produced by a cross-fertilization of *Juglans californica* and *J. nigra*. The name is applied to any tree that is the offspring of cross-fertilization between these two species (Pl. II).

Rush.

Parisienne type; medium; roundish oblong to oblong, occasionally somewhat oblique; base obtuse truncate; apex very slightly rounded or even depressed; scarcely mucronate; sutures appressed or slightly ribbed, usually slightly pitted at the equator; flange broad, very firmly sealed; shell grayish brown, roughened by numerous small, shallow depressions, longitudinal lines inconspicuous; diaphragm firmly shouldered, strong and persistent; kernel full, convolutions moderate; pellicle light golden tinge, slightly astringent, glossy; velvety moderate and dark; flesh medium texture, moderately oily; flavor sweet, rich; quality good. *Origin*: Chance seedling in 1886, with J. G. Rush, West Willow, Pa.; specimens grown by Mr. Rush, crop of 1910 (Pl. VII).

Santa Barbara.

Type; above medium to large; form variable, oblong or broadly oblong, the lower half frequently tapering and occasionally oblique; base rounded; apex obtuse to acute with mucronate tip or firm point; sutures medium to strongly ribbed or sometimes appressed, not infrequently pitted at the equator; flange variable, firmly sealed; shell moderately thin, grayish, or yellowish; from quite rough to moderately smooth, longitudinal lines negligible; diaphragm rather weakly shouldered, thin and scarcely persistent; kernel full, rather plump, convolutions moderate, irregular and broken;

pellicle yellowish brown, slightly astringent, glossy, veins rather numerous, especially the smaller ones noticeable; flesh rather dry; flavor moderately sweet; quality good to very good. *Origin*: Chance seedling from nuts thought to have been imported from Chile planted in Santa Barbara County, Cal., by Joseph Sexton in 1886; specimens grown on La Patera Ranch, crop of 1910 (Pl. IV).

The type of this variety is extremely variable in minor details, a result of the practice of propagating from nuts selected to meet the ideas of the respective growers. While these ideas coincide in a general way, there are marked differences as to form, and at best growers do not confine themselves closely to definite ideals. It is easily understood that the production of uniform nuts is difficult to attain from seedlings, and so long as this method is pursued we can hardly expect to have other than a very variable type.

Santa Barbara (More form).

The favorite form of the Santa Barbara as selected by John F. More; somewhat more angular than the nut described; a more pronounced apical point; rougher; sutures more strongly ribbed. Specimens grown by Mr. More, crop of 1910 (Pl. IV).

Santa Barbara (Williams form).

An improved form of Santa Barbara selected by George M. Williams. The sutures are more appressed and the nut smoother, though in other respects conforming closely to the general type of this variety as now propagated in southern California. Specimens grown by Mr. Williams, crop of 1910 (Pl. IV).

Santa Barbara Softshell.

Synonym of Santa Barbara.

San Jose Mayette.

Synonym of Wiltz.

Santa Rosa.

Santa Barbara type; above medium to large; oblong with broadly oblong or tapering lower half; base rounded and commonly oblique; apex acute or obtuse with strong point; sutures strongly ribbed, rarely pitted at the equator; flange variable, only moderately sealed; shell thin, grayish to yellowish, roughened particularly along the sutures by irregular depressions, pits, and protuberances, longitudinal lines infrequent, occasionally well defined; diaphragm firmly shouldered, generally thin and weak, rarely persistent; kernel full, moderately plump, convolutions pronounced and variable; pellicle rich yellowish brown, glossy, astringent, veins rather sparse, but generally well defined; flesh oily, rich; flavor sweet; quality good. *Origin*: Chance seedling at San Francisco years ago, but later moved to Santa Rosa, where it now stands; first introduced by Luther Burbank in 1882-83; specimens grown by George C. Payne, crop of 1910 (Pl. IV).

Serotina.

Franquette type, modified; small; ovate, occasionally somewhat oblong; base obtuse to truncate; apex acute to acuminate, with strong point; sutures appressed at the base, moderately to strongly ribbed above, pits at the equator, narrow and deep; flange moderate, very firmly sealed; shell yellowish, smooth, rather thin, longitudinal lines usually well defined; diaphragm thick, strongly shouldered, and often more or less persistent. *Origin*: Europe; specimens grown by Felix Gillet; second generation, crop of 1891 (Pl. VIII).

In a brief description of this variety in 1887-88, Mr. Gillet said: "This variety is of especial value for planting in those districts where late spring frosts prevail, as it is very late in vegetating. The tree is very prolific and the nut is of medium size, well shaped, with a very sweet and highly flavored kernel."

Sexton.

Originated with Joseph Sexton, in California, but not a well-defined variety with individual merit, and not propagated.

Sexton's Papershell and Sexton's Softshell.

Synonyms of Santa Barbara.

Sinclair.

Parisienne type; above medium to large; broadly oblong; base obtuse truncate; apex obtuse to slightly retuse, with mucronate tip; sutures appressed at base, slightly ribbed; irregularly if at all pitted at the equator, which is above a median line; flange narrow, firmly sealed; shell medium thick, pleasing yellow, moderately smooth, though the abundant veining gives it the appearance of roughness, longitudinal lines usually present and well defined; diaphragm strongly shouldered, rather thick, and somewhat persistent; kernel full, plump, convolutions moderate and variable; pellicle dark, semiglossy, very astringent; veins ample and dark; flesh crisp, rather oily, and starchy; flavor insipid; quality fair. *Origin:* A seedling on the property of L. J. Onion, Harford County, Md.; specimens from Mr. Onion, crop of 1911 (Pl. IX).

Smith's Favorite.

Synonym of Favorite.

Stocktonian.

Franquette type, slightly modified; large; oblong to oblong ovate, or even occasionally elliptic; base obtuse or irregularly rounded; apex obtuse to acute with short, strong point; sutures rather strongly ribbed, indifferently pitted toward the base; flange broad and quite firmly sealed; shell moderately thin, bright yellow, somewhat roughened by various irregular depressions, longitudinal lines almost absent; diaphragm strongly shouldered, rather heavy and persistent; kernel only moderately full, not plump, convolutions variable, but usually pronounced; pellicle dull, light brown, astringent; veins inconspicuous; flesh starchy, oily; flavor indifferent; quality fair. *Origin:* E. M. Price says: "It is a seedling of Serotina; bears every year, and is prolific; blossoms early and has not yet been affected by blight." Specimens supplied by E. M. Price, crop of 1910.

Teague.

Santa Barbara type; medium, though rather variable in size and also form; roundish oblong to broadly oblong with decidedly tapering base in many specimens; base obliquely obtuse to rounded or even acute; apex obtuse or acute, mucronate tip to firm point; sutures moderate to strongly ribbed, rarely pitted at the equator; flange usually broad, firmly sealed, though frequent specimens are imperfectly closed; shell thin, yellowish, varying from quite smooth to roughened by numerous irregular shallow depressions and protuberances, longitudinal lines rarely noticeable; diaphragm weakly shouldered, thin, and scarcely persistent; kernel very full and plump, convolutions variable, moderate; pellicle light yellow tinged with brown, dull, semiglossy, slightly astringent, veins numerous and brown to dark brown; flesh oily; flavor moderately sweet; quality fair. *Origin:* Chance seedling of the Santa Barbara; planted in Ventura, Cal., in 1886, and reputed to be blight immune; specimens grown by Dana L. Teague, crop of 1910.

Thinselled.

A variety catalogued by the Georgia Horticultural Society, report for 1900; possibly Hightstown, which has sometimes passed under the name of Thinselled.

Titlark.

Synonym of Mesange.

Treyve.

Parisienne type; above medium; oblong, with an appearance of angularity; base obtuse; apex obtuse, mucronate; sutures slightly ribbed to appressed, usually strongly pitted at the equator; flange moderately broad, firmly sealed; shell brownish, mottled with gray, slightly roughened, with scattered shallow depressions and pits along the sutures, longitudinal lines depressed, generally indistinct or broken, though occasionally well defined; diaphragm strong and firmly shouldered; kernel moderately full, convolutions medium to large; pellicle very light, semiglossy, astringent, veining indistinct; flesh moderately oily; flavor moderately sweet, mild; quality good. *Origin*: France; specimens grown by Ely I. Hutchinson, crop of 1910 (Pl. VII).

Vilmorin.

A hybrid between *Juglans regia* and *J. nigra*, originating in France and introduced into the United States by Felix Gillet. "The nut has the shape of the Persian walnut, or rather that of *Serotina*, and the shell the appearance and hardness of the black walnut. A very curious nut, but not desirable for market."¹

Volga.²

Medium; long, ovate; shell quite thin; quality good; grown by the writer from nuts picked up at Saratov, on the Volga, in Russia. It proved hardy enough to endure winters in central Iowa, and is now propagated in Missouri.

Vourey.

Franquette type, modified; small to medium, broadly oblong ovate; base obliquely truncate; apex obtuse to acute, with firm point; sutures strongly ribbed, broadly pitted at the equator; flange narrow, firmly sealed; shell yellowish, thin, roughened by numerous irregular depressions and protuberances; diaphragm firmly shouldered, thin, though frequently persistent. *Origin*: Near Vourey, in southeastern France; specimens grown by John Rock, California Nursery Co., crop of 1891 (Pl. VIII).

Of this variety the late Felix Gillet said, "It is much the same form as Parisienne and possesses its superior quality." Of its quality the writer can not speak, since the material from which the above description was made was 9 years old, rancid, and worm-eaten; but the form, while very unlike a Parisienne, much resembles Franquette, more particularly its upper two-thirds, with a decidedly truncate base (a Mayette character), and the same strongly ribbed sutures, with an extended, firmly pointed apex. It is evident that the Rock and Gillet types of Vourey are not the same, but quite different nuts. Upon the general character of the Vourey, Berthet remarks, "This variety holds a middle place between Mayette and Franquette; it is smaller than the first and as rustic as the second." He adds that it is a dessert nut and is later than Mayette by 15 days.

¹ Catalogue, Barren Hill Nurseries, 1887-88.

² J. L. Budd, American Horticultural Manual, pt. 2, 1903.

From the above statements it appears that the Rock type is approximately true to the French standard and quite possibly would serve as a parent for American stock.

Ward.

Cahor type; medium to slightly above; oblong; base rounded; apex obtuse to acute, mucronate tip; sutures appressed or very slightly ribbed, rarely pitted at the equator; flange narrow to variable, firmly sealed; shell rather thin though strong, grayish brown, moderately smooth to roughened by wavy and slightly raised convolutions and narrow depressed veins, longitudinal lines rarely present; diaphragm weakly shouldered, thin, though somewhat persistent; kernel full, plump, convolutions regular, even, and pronounced; pellicle light yellow to brownish, dull, very slightly astringent; flesh crisp, slightly oily, rich; flavor sweet; quality fair to good. *Origin*: Accidental seedling with W. H. Ward, Morgan Hill, Cal., about 1897; tree hardy, prolific, thus far free from blight; specimens grown by Mr. Ward, crop of 1910 (Pl. V).

Weaver.

Fertile type, modified; small; oblong; base rounded to obliquely obtuse; apex obtuse to slightly acute, mucronate tipped; sutures slightly ribbed to somewhat appressed, more or less pitted at the equator; flange rather broad, very firmly sealed; shell brownish gray, thick, slightly roughened by numerous small, irregular depressions and an occasional pit, longitudinal lines usually present though more or less irregularly broken; diaphragm firmly shouldered, thick and persistent; kernel full, plump, convolutions very moderate, broken, and variable; pellicle brownish yellow, dull, slightly astringent; veins inconspicuous or rarely well defined; flesh oily, starchy, rather coarse; flavor insipid, scarcely sweet; quality poor to fair. *Origin*: Chance seedling on the Weaver estate near Martinsburg, W. Va.; reputed to be approximately 75 years of age and a regular and heavy bearer; specimens from the original tree, crop of 1910.

Weeping.¹

Probably a synonym of *Juglans regia pendula*. Felix Gillet says: "Still another new and valuable variety; it derives its name from its branches drooping under the weight of nuts, we presume, like a weeping willow." Further than this we have found no record of the variety in the United States.

Willson.

A large nut of the Bijou type originating in Santa Clara County, Cal., about 1910; said by the introducer to be very precocious, productive, and blight proof.

Willson's Acme.

Synonym of Acme.

Willson's Wonder.

Synonym of Willson.

Wiltz.

Mayette type; large, broadly oblong, sometimes narrowed at base; base slightly rounded to obtuse; apex obtuse, acute pointed; sutures slightly ribbed to appressed, usually pitted at the equator; flange narrow, occasionally imperfectly sealed; shell very thin, light yellowish, moderately smooth with depressions about the sutures, longitudinal lines depressed and well defined; diaphragm weak shouldered and thin; kernel full, con-

¹ Catalogue, Barren Hill Nurseries, 1887-88.

volutions pronounced; pellicle light, semiglossy, very slightly astringent; veining inconspicuous; flesh moderately oily; flavor sweet; quality very good. *Origin*: Chance seedling discovered on the Stevens Road near San Jose, Cal., about 1892; specimens grown by R. Wiltz, crop of 1910 (Pl. XI).

This is another of the varieties recommended for trial by the University of California as promising in the work against blight.¹ The fact that one tree in the home orchard of Mr. Wiltz has grown for nine years between two trees of other varieties and while they are more or less affected with blight each year it remains free is excellent evidence that this variety promises to be blight resistant. Before positive statement can be made there must be extended trial over a wide area under variable conditions. Should it stand the test it will be widely planted, for it possesses several qualities esteemed by the dealer and consumer, being of excellent size, form, and color and of good quality and flavor. The nuts are quite uniform, with a small percentage of culls, and the tree is fairly productive, though not a robust grower. Mr. Wiltz states that the trees may be set in permanent orchard at 30 feet apart and have ample room. This is based on the growth of the tree upon its own roots. It is quite probable that the variety would make a larger growth upon the native black or hybrid stocks.

Wiltz Mayette.

Synonym of Wiltz.

WEIGHT AND MEASUREMENT.

Table II gives the weight and measurement of several hundred average specimens of Persian walnuts from the crop of 1910. The weights were made in February, 1911. The nuts had been stored so as to insure dry specimens under uniform treatment. The figures are merely approximate, as the weight of nuts varies from year to year. The variation in both the development of the kernel and in the thickness and weight of the shell depends upon climate, soil, food, and water. These figures may serve as a basis for more comprehensive work in future investigations. Allowance must be made for the personal equation in the fact that different people selected the average specimens of several varieties.

The weight gives the number of nuts to the pound; the measurements are of diameters in inches (1) at right angles to the sutures, (2) in the plane of the sutures, (3) from base to apex. The French Mayette, as sold on the New York market for 1910, is used as a leader, merely for comparative purposes.

¹ Bulletin 203, California Agricultural Experiment Station.

TABLE II.—Average weight and size of typical specimens of Persian walnuts, by varieties.

[Varieties illustrated in the plates are indicated by an asterisk (*).]

Variety.	Nuts to the pound.	Diameter (in inches).			Variety.	Nuts to the pound.	Diameter (in inches).		
		(1) Across sutures.	(2) Plane of sutures.	(3) Longi- tudinal.			(1) Across sutures.	(2) Plane of sutures.	(3) Longi- tudinal.
Alpine*		1.47	1.48	1.81	Meylan*				
Barnes.....	45	1.26	1.25	1.43	(Hutchinson).....	37	1.47	1.30	1.45
Bijou*.....	24	1.58	1.68	1.80	Meylan*				
Chaberte*.....	53	1.17	1.05	1.30	(Prince).....	47	1.42	1.30	1.41
Chase*.....	30	1.47	1.44	1.80	Milbank*.....	39	1.30	1.28	1.52
Chelan*.....	50	1.18	1.17	1.53	Mount*.....	45	1.17	1.18	1.21
Concord*.....	40	1.31	1.22	1.53	Nebo*.....	32	1.47	1.39	1.50
Cumberland*.....	41	1.25	1.22	1.33	Neff*.....	36	1.42	1.33	1.86
Eureka*.....	33	1.20	1.18	1.80	Parisienne*.....	36	1.41	1.30	1.52
Fertile* (Hutchinson).....	48	1.15	1.13	1.47	Payne*.....	44	1.31	1.34	1.72
Fertile (Prince).....	54	1.13	1.08	1.40	Payou*.....	26	1.61	1.42	2.63
Ford*.....	30	1.47	1.37	1.72	Placencia*.....	40	1.31	1.25	1.50
Franquette (Hutchinson).....	39	1.27	1.25	1.60	Persian*.....	49	1.18	1.18	1.36
Franquette* (Vrooman).....	36	1.31	1.34	1.87	Pomeroy*.....	54	1.08	1.09	1.34
Glady*.....	30	1.63	1.45	1.87	Prince*.....	36	1.33	1.22	1.80
Hales*.....	41	1.22	1.30	1.62	Prolific.....	37	1.32	1.25	1.77
Honeydew*.....	34	1.44	1.30	1.75	Rush*.....	45	1.27	1.17	1.33
Hubbard*.....	43	1.16	1.11	1.64	Santa Barbara*.....	39	1.32	1.27	1.20
Journeay*.....	37	1.34	1.25	1.61	Santa Rosa*.....	38	1.38	1.28	1.59
Keesling*.....	37	1.26	1.28	1.53	Sinclair*.....		1.31	1.28	1.45
Hall*.....	26	1.55	1.44	1.67	Sorrento* (Italian).....	49	1.11	1.08	1.55
Holden*.....	40	1.30	1.23	1.63	Teague*.....	50	1.23	1.17	1.37
Kaghazi*.....	35	1.38	1.31	1.70	Treyve*.....	37	1.34	1.22	1.45
Klondike*.....	35	1.42	1.25	1.84	Ward*.....	45	1.20	1.13	1.50
Mayette*.....	44	1.33	1.22	1.44	Weaver*.....	60	1.03	1.03	1.31
Mayette (French grown).....	54	1.25	1.18	1.41	Wiltz*.....	37	1.48	1.43	1.78

PROPAGATION.

The problem of the best way to propagate the walnut is of long standing, though for obvious reasons the present interest is greater than at any time in the past. Nearly a hundred years ago (1818) Thomas Andrew Knight, writing of the propagation of the walnut, said:

The advantages of propagating varieties of the walnut tree by budding will, I think, be found considerable, provided the buds be taken from young or even middle-aged healthy trees; for, exclusive of the advantage of obtaining fruit from very young trees, the planter will be enabled to select not only such varieties as afford the best fruit but also such as endure best, as timber trees, the vicissitudes of our climate. In this respect some degree of difference is almost always observable in the constitution of each individual seedling tree, and this is invariably transferred with the graft or bud. * * *

The buds of trees of almost every species succeed with most certainty when inserted in the shoots of the same year's growth. But the walnut tree appears to afford an exception, possibly in some measure because its buds contain within themselves in the spring all the leaves which the tree bears in the following summer, whence its annual shoots wholly cease to elongate soon after its buds unfold. All its buds of each season are also, consequently, very nearly of the same age, and long before any have acquired the proper degree of maturity for being removed the annual branches have ceased to grow longer or to produce new foliage. * * *

There are at the base of the annual shoots of the walnut and other trees, where those join the year-old wood, many minute buds which are almost concealed in the bark, and which rarely or never vegetate but in the event of the destruction of the large prominent buds which occupy the middle and opposite end of the annual wood. By inserting in each stock one of these minute buds and one of the large and prominent kind I had the pleasure to find that the minute buds took freely, whilst the large all failed without a single exception. This experiment was repeated in the summer of 1815 upon two yearling stocks [with equal success]. * * *

The most eligible situation for the insertion of buds of this species of tree and probably of others of similar habits is near the summit of the wood of the preceding year and, of course, very near the base of the annual shoot; and if buds of the small kind above mentioned be skillfully inserted in such parts of branches of rapid growth they will be found to succeed with nearly as much certainty as those of other fruit trees, provided such buds be in a more mature state than those of the stocks into which they are inserted.¹

Later (1832) Mr. Knight said:

The walnut tree appears hitherto to have effectually baffled, under all ordinary circumstances, the art of the grafter. * * * [It] may be propagated with more success by budding. I have succeeded tolerably well in some seasons and in one season perfectly well, but in several others not a single inserted bud has been found alive in the following year, though all had been inserted with the greatest care.²

Mr. Knight also stated that he found the following mode of grafting perfectly successful in 1831 under many unfavorable circumstances: Allow the primary buds to unfold on both stocks and scions; then remove the opened buds, and after the small secondary or tertiary buds, which have been previously almost invisible, begin to swell, take off the scions and immediately insert upon the stocks, which should be of wood of the previous year. Saddle or cleft grafting is equally successful, though with both modes of operating it is advantageous to pare away almost all of the wood of the scion, the large pith of the young walnut in this case being of no inconvenience to the operator.³

The French author Berthet,⁴ writing upon this topic some years ago, said:

It is noticeable that the walnut, especially when not grafted, seasons very often; that it is to say that the harvests are not equal from year to year; an abundant harvest may be followed by a very poor one.

Speaking of the importance of grafting as a means of propagating the walnut, J. B. Neff,⁵ a grower of high-grade stock and originator of the Neff nut, says:

The average seedling walnut orchard is not a success for several reasons: The nuts are uneven in size and form, the trees are not equally productive

¹ Transactions of the Horticultural Society of London, ser. 1, vol. 3, 1820, pp. 133-135.

² Idem, ser. 2, vol. 1, 1835, pp. 214-215.

³ Idem, pp. 215-216.

⁴ Annales des l'Institut National Agronomique, sér. 2, 1897, p. 34.

⁵ Personal communication.

and are largely subject to blight. It may be said that one-fourth of the trees produce a few nuts, another one-fourth produce about enough to pay the expenses of their own care, thus leaving one-half to pay such profit as may be obtained from the whole.

From this statement, which appears conservative, of the views held by one of the best-informed growers of the Pacific coast, the profits of an orchard of seedling trees are not over one-half what they should be if the trees were grafted. The profits on an orchard of grafted trees should be considerably larger if judicious care is taken in the selection of both varieties and stock. If it be true that seedling trees are more liable than grafted ones to attack by blight bacteria, it is probable that the revenue would be more than double that derived from the average seedling orchard. It must be kept in mind that there is much difference of opinion among growers and propagators as to what are the best stocks and varieties for specific localities. Much of this divergence of opinion among leading growers is due to the fact that experimentation in the propagation and improvement of the walnut in the United States is in the earliest stages.

Notwithstanding the success of Mr. Knight in budding the walnut, the method of propagating commercially has been to plant the nuts, except to a limited extent as in the Grenoble district, where the practice of grafting some of the best strains of the Mayette, Franquette, and Parisienne has been followed for some years.

The earliest walnut orchards of California were grown from nuts purchased in the open market. After these orchards began to bear it was noticed that some trees produced more and better nuts than others. Then followed a period in which the growers selected nuts from trees that were heavy bearers or that yielded a product of a higher quality, better form or color, thinner shell, or earlier maturity. This seed-selective method produced several improved varieties, some of which should be propagated with a greater degree of certainty than is possible by seedage.

It has been found that the walnut is like the apple, the pear, the peach, and the plum; there are only two ways of propagating a variety with certainty—by budding and by grafting. Thus, it has come about after centuries of cultivation that advanced students and successful growers agree that budded or grafted trees should be used in starting a commercial orchard. Trees true to name are now propagated almost exclusively by grafting, but experiments during the past year or two by several propagators, notably Kraus, of Oregon, indicate that budding will soon take rank with if not supersede the grafting process.

STOCKS.

The two important elements in propagating the walnut true to type, variety, or name are the stock and the scion. The consensus of opinion is that the two native black walnuts, together with the rock walnut of Texas, are the stocks par excellence on which to graft the Persian walnut. The most enlightened propagators and growers recommend *Juglans rupestris* for Texas and the Southwest; *J. californica*, southern form, for the foothills and interior valleys of southern California; *J. californica*, northern form, for the coast region and interior valleys of northern California and southern Oregon, including the Umpqua Valley; *J. nigra* or *J. californica*, northern form, for the Willamette Valley in Oregon and the Columbia Valley in both Oregon and Washington; and *J. nigra* for the eastern United States. Further investigation of the merits of these stocks through extended plantings may modify these conclusions, particularly as to interior California and the Willamette and Columbia Valleys.

R. Wiltz, a propagator of considerable experience, in discussing the merits of stock for California, says:

For our conditions in general I am convinced that the northern California black as a stock for the Persian can not be excelled. It grows 40 to 50 per cent faster than the eastern black, has a vegetative season four to six weeks longer, is inured to our conditions through ages of natural selection, is one of the deepest rooted trees that we have, is a rapid grower, has thus far been free from diseases, is exceedingly prolific under the most trying conditions, and readily accepts grafts of all strains of the Persian.¹

Harvey C. Stiles says of *Juglans rupestris*:

It is a very handsome tree, well worth growing for its beauty, shade, and fruit, but its great value lies in its use as a stock on which to work the English (properly Persian) varieties. * * * On that root English walnuts are succeeding in parts of California and Arizona where they failed utterly on their own roots. * * *

The English walnut is very intolerant of mineral soil salts even at considerable depth and the trees, even after growing well for several years, will die back when the roots reach such soil strata. On the other hand, this *rupestris* is found almost only in a natural state on strongly mineralized soils and in hot arid regions.²

G. A. Schattenberg,³ writing of the walnut industry in southwestern Texas, states that the English walnut on its own root vegetates too early in the spring for his region. He says that the future of walnut growing in Texas lies in the use of *Juglans rupestris* top-grafted, and

¹ Personal communication.

² Stiles, Harvey C. Walnuts in Southwest Texas. Bulletin 2, Texas Dept. of Agriculture, 1908, p. 43.

³ Schattenberg, G. A. The Future of the Walnut Industry in Southwest Texas. Bulletin 2, Texas Dept. of Agriculture, 1908, p. 42.

that a few trees of *J. rupestris* top-grafted with the variety Franquette have made in eight years a growth of 10 feet and have borne in succession four or five crops of fine nuts without irrigation.

Since the above was written (1907) Mr. Schattenberg finds that his Persian walnut grafts on *Juglans rupestris* suffered severely in recent winters and particularly from autumn frosts. These results cast doubt on the opinions previously expressed, and the suggestion is here offered to use caution in planting the walnut in localities not fully tested.

F. T. Ramsey, Austin, Tex., says:

Three or four years ago it occurred to us that English walnuts could be successfully and profitably grown by budding upon our native walnuts. We have been over 30 years trying to grow them upon their own roots, but have failed to obtain a nut. Four years ago we obtained direct from the woods some small trees of our native dwarf walnut, which we call *Juglans rupestris*, and after they had stood a few weeks in the nursery row we budded them. The first year we obtained a growth of about 6 inches, but since then they have grown from 3 to 6 feet each year. We now have nearly all of the California varieties, besides the Rush, Hall, and Nebo from Pennsylvania. One of these trees, Franquette, set a nut last year, but it was accidentally destroyed before maturing. We find by "ring budding" that the walnut may be propagated with ease. Thus far summer droughts and unexpected frosts have not injured a single tree. Our native walnuts vary considerably. Some trees produce a nut the size of a small marble, while others produce them half the size of an eastern black. I have been distinguishing these by the names *Juglans rupestris minor* for the small one and *J. rupestris intermedia* for the larger one. We find that the English buds will grow from two to four times as rapidly upon the former as upon the latter during the first year, so far as observed. This *minor* variety often bears a heavy crop while only 3 or 4 feet tall; the best of them can hardly be called trees, though some of them reach the height of 20 or 30 feet. I believe we will find good, profitable walnut orchards growing all over the prairies from here to Kansas.¹

Should the expectations of Mr. Ramsey be realized by half, great value will attach to *Juglans rupestris* stock, but it must be kept in mind that these views are based on very limited experiments.

GROWING THE STOCK.

The nuts for stocks should be selected from robust, vigorous, healthy, fruitful trees of the desired species, growing under conditions that prohibit cross-pollination. After being harvested they should be layered or planted where rodents will not molest them. The method of layering will depend upon the quantity to be handled. If the quantity is small, they may be layered in the manner usually followed by nurserymen—in flats or shallow boxes easily handled by one person. If the quantity is large, lay a plank floor on the leeward side of a building with sides 6 or 8 inches high; cover the

¹ Personal correspondence, 1911.

planks with 2 inches of clean, moist sand, spread a layer of nuts, over these an inch more of sand, and continue until all the nuts are layered. On the topmost layer of sand place a light covering of straw, shavings, or leaves to prevent wash or drift, and over all stretch a fine-mesh wire netting to keep out rodents.

In the spring as soon as sprouts issue from the opening nuts they may be taken from the layering bin and planted in the nursery in the same manner as though unsprouted. As the young shoots are very brittle, extreme care must be exercised in planting; otherwise considerable or even irreparable injury results. If the ground about the nursery site is free from the depredations of rodents, the nuts should be planted at once, in regular nursery rows, upon harvesting or receiving them.

The nursery site should be high, well drained, with an open exposure and a soil that is deep, friable, and fertile without excess of humus. Unless the subsoil is thoroughly porous, the ground should be prepared by deep plowing and subsoiling. The rows should be 4 feet apart and should lie east and west, so that in the operation of budding the buds may be readily inserted on the north side. In planting the nuts they are placed about a foot apart in the row and 1 to 3 or 4 inches deep, according to the species. The small nuts of *Juglans rupestris* may be planted not more than 1½ inches deep, the larger nuts of *J. californica* and Paradox may be safely placed at 2 to 3 inches, and the still larger nuts of *J. nigra* and Royal at 3 to 4 inches. In planting nuts in the nursery rows the first stages of growth of the young trees may be facilitated by placing the nuts with their sutures in a vertical plane. As the root and shoot both issue from between the opening valves, it is readily understood how this may enable the seedling to effect an erect position almost from the moment of its germination, thereby hastening its appearance above ground and thus promoting its first stages of growth.

NURSERY TILLAGE.

Give the young trees such tillage as will insure a fine, powdery, surface soil. Care should be exercised at all times to avoid rolling clods against the young trees and thus diverting them from an erect growth, or by bruising the bark or terminal buds. If grown in a good soil thoroughly tilled, 30 to 50 per cent of the seedlings will be large enough for crown grafting the following spring. A conservative grower would discard the remainder.

SCIONS.

The scion wood should be selected with extreme care, as much or more than is accorded the selection of the stock. Only the best of

trees should be drawn upon for scion wood. Trees that are tainted with blight, that are imperfect pollinators or that mature their staminate and pistillate blossoms at separate dates, that are indifferent bearers, that are unthrifty growers, that have a sprawling irregular habit, or that are prone to fitful activity in the spring should be avoided. From suitable trees take the normal 1-year-old wood from the middle more or less erect portion. Under no circumstances use suckers, water sprouts, or trailers. Such wood rarely produces fruit, and though there is no direct evidence against it, the presumption may be advanced that it is not the best for the purpose. Scion wood should be one-fourth to three-eighths of an inch in diameter, straight, clean, thrifty, plump about the buds, tubular not angular, with short internodes and small pith, preferably not over a foot long, which is long enough, without using the terminal bud, for two or three scions. This statement is not intended to imply that wood of greater or less length than 1 foot is not suitable for grafting but rather that the kind described is ideal. Often the later growth of a season is not properly ripened; hence the frequent unfitness of terminal buds, especially on growth over a foot in length. Scions should be cut during the period of dormancy, probably two or three weeks before vegetation begins, say February or March, according to location and season. Immediately after cutting, the cut ends should be dipped into melted paraffine or other tenacious and impervious substance, so that evaporation from the cut part may not reduce the vitality of the scion. After the cut ends are waxed or smeared tie the scions in small bundles, wrap with moist moss or vegetable fiber, and put in a cool place until needed. Occasional inspection should be made to insure against attacks of fungi, such as molds, in case the temperature of the receiving space becomes too high. Another method of preserving scions practiced in California is as follows: In a box on a layer of clean moist sand 2 inches deep place a layer of scions, chink between these additional sand, then another layer of scions and more sand, and so on until the layers of scions are 2 to 3 inches deep, and cover all with 2 inches of sand and set the box away in a cool place. Occasionally examine the soil to see that it does not dry out and shrivel the buds, and on the other hand avoid moisture sufficient to start the buds prematurely.

TOOLS.

Perhaps the most important part of grafting is to have first-class tools. The knife for preparing stocks and scions, especially in trimming the cambiums, should be of the best material, so that a sharp edge may be constantly maintained. Other tools, such as a splitting

knife (which may be a heavy long-bladed butcher knife), a shoemaker's knife for nursery grafting, a budding knife of the usual form, a double-edged saw, and an oilstone with one face of emery, should likewise be of the best material. Additional tools are a mallet, two or three small wedges of iron or hard wood, a wax pot with a warming device, a wax brush, cotton cloth, twine, bicycle tape, and cloth parcel tags. The wedges should be 6 or 7 inches long and of different widths to use with branches of varying size. The shape of the taper should be such that the edges are thinner than the middle. A wedge of such form will keep its position in the cleft and may be removed readily at the close of the operation by a slight side-wise movement without disturbing the scions. A galvanized-iron pail or coal-oil can with the top cut away and four wires stretched across, two each way at right angles 8 inches from the bottom, will serve as a support for the wax pan. The space below the wires holds a gasoline blowtorch, or a fire may be built in the bottom on a layer of earth or puddled clay to keep the wax melted.

GRAFTING.

The details of methods of grafting by leading propagators differ, but not enough to be considered distinct systems. The instructions here given are adapted from George C. Payne and R. Wiltz. The principles applied to grafting deciduous fruit trees apply to the walnut, but the following precautions should be observed: (1) Great care must be exercised to have dormant wood for scions; (2) the grafting must be done just as the leaf buds of the stock are unfolding; (3) the cambium of stock and scion must be brought into exact contact; (4) the cleft in the stock for the reception of the scion shall be clean cut and so made as to grip the tongue of the scion firmly; (5) the scion shall be made from carefully selected wood with a clean, smooth-cut tongue; and (6) the wound shall be covered with adhesive wax or paste impervious to water or air¹ until the union of stock and scion is fully effected. The treatment of the wound necessitates frequent inspection in order that rewaxing may be done where cracking or melting may permit air to reach the cut surface of stock or scion. Nothing must be left undone to insure an air-tight graft and to prevent evaporation from the scion.

Numerous modes of grafting and budding have been employed with the walnut and among the more successful are cleft, saddle, whip-and-tongue grafting; annular, flute, prong, shield, and chip budding.

¹ In the walnut-grafting operations at the Arlington Experimental Farm in the spring of 1912, plasticine or modeling clay was used with excellent results. In fact, a larger percentage of successful grafts was obtained with plasticine than with wax, as the former does not dry and crack like the latter.

The time for grafting is just as the trees begin to vegetate, or while the leaves are unfolding. If top-working the Persian walnut, it is advisable to begin operation somewhat earlier than if grafting the black-walnut stock, as the former has a more abundant sap flow dur-



FIG. 1.—Cleft grafting: First position of the knife when making a cut.

ing the first few days of vegetative activity. It is possible to successfully graft the black walnut after the leaves have quite fully unfolded, while best results with the Persian stock are obtained by grafting just as the buds are fully swollen. The grafting of nursery stock is attended with variable results. In some years propagators are widely successful, during other seasons only a few obtain favorable results. No satisfactory explanation has been made for this uncertainty, though most propagators ascribe it to seasonal conditions and to lack of specific information for the problems in hand. The operator should avoid bleeding nursery stock by grafting as soon as possible after the slipping of the bark and discontinue before the sap becomes free flowing. Budding

may be done at any time when the bark will slip readily and when well-formed dormant buds can be procured.

The following directions for cleft grafting will apply in all essentials to the other modes of grafting: Prepare the stock which, preferably, should be not more than 2 or 3 inches in diameter, by making a smooth, clean-cut surface. In top-working old or large trees it is often desirable to graft limbs of a diameter larger than 3 inches, in which case additional care must be exercised in the operation and more scions set in each stock.

In sawing off the stock use great care not to split the bark. If the stock to be sawed off is a substantial branch of a full-grown tree the same care must be given as in pruning; otherwise back splitting will



FIG. 2.—Cleft grafting: Second position of the knife when making a cut.

occur, with great inconvenience to the operator and damage to the tree. To avoid back splitting, follow the directions for removing large branches in pruning (p. 83). After the stock is prepared, split it along two lines (figs. 1 and 2), using care to keep the knife in the positions shown, so that as it is driven into the stock it will cut the bark first; if the stock is large, split it along four lines (fig. 3).

After the bark has been split $1\frac{1}{2}$ to 2 inches deep on both sides of the stock, change the knife to the third position (fig. 4) and complete the cleft.

If a horizontal branch is to be grafted make the cleft crosswise rather than vertical, so that the scion may be inserted on the side. Scions inserted upon the upper face of a branch rarely grow, while those on the sides do quite as well as when placed upon vertical branches. After removing the knife insert a small wedge to hold the cleft open until the edges can be smoothly dressed and the scions inserted (fig. 3).



FIG. 3.—Cleft grafting: Large stock of Persian walnut split to receive four scions. The clefts are not made entirely across the stock; i. e., each split is made from one side only.

PREPARING THE SCION.

If the scion wood has been properly selected it will be an easy matter to make two or three suitable two-bud scions from each of the sticks of scion wood. Where the wood is not uniformly good, select only that which has little pith, strong but not large buds, and firm wood. The lower end of

the scion should be $1\frac{1}{2}$ to 2 inches below the lower bud, the upper end one-fourth to three-eighths of an inch above the second bud of the



FIG. 4.—Cleft grafting: Third position of the knife when making a cut.

scion. The tongue of the scion should be about $1\frac{1}{2}$ inches in length, of an easy, straight taper, and with the outside somewhat thicker than the inside (figs. 5 and 6). In placing the scions use the utmost care to have the tongue of the scion fit the cleft

snugly, and so placed that the cut edges of the inner bark of both stock and scion come in contact over as long a space as possible.

On removal of the wedge the cleft will firmly grip the scion and safely hold it till the operation is complete. The final step is to wrap the stock firmly with a cotton band (fig. 7) 3 or 4 inches wide and to cover with wax the entire wounded

surfaces of both stock and scions, including all breaks in the bark at the base of the cleft. If the cleft remains widely open after the wedges are removed the space may be choked with old newspaper or similar material before the stock is waxed over. This packing should be pushed below the

cut surface of the stock so that waxing will leave no breaks whereby air may enter. After waxing is complete (fig. 8) draw over the whole a paper bag (fig. 9) and tie it firmly about the stock a few inches below the lowest point of the cleft. When the scions indicate that union has taken place, the cotton band may be



FIG. 6.—Cleft grafting: a, Scion inserted in the cleft; b, the completed graft wrapped and waxed.



FIG. 5.—Cleft grafting: Scion prepared for insertion.

cut through at one or two places to prevent restricting the circulation of sap. The other modes of grafting differ from the above only in minor details (figs. 10 and 11).

CARE OF THE GRAFT.

It is necessary in grafting and budding that no air reach the cambium of either scion or stock. Frequent inspection of grafts should be made and all pores and cracks rewaxed. If the waxing was well done at the start and the paper bags carefully adjusted and firmly tied it is not likely that much rewaxing will be needed. As soon as the grafts are nicely started the bags may be broken open, preferably on the north side, so that light may be admitted. In a few days thereafter the bags may be entirely removed.

As soon as the grafts are well established provision must be made for supporting them against winds. For this purpose strips of lumber 1 by 2 inches are firmly nailed to the stock in such positions as will permit of tying the young growth to them.

As the growth of grafts, especially when placed upon large and vigorous stocks, is very strong, these supports need to be from 8 to 12 feet long in order to give the desired protection (fig. 12). The grafts should be tied with strong soft cord or cloth bands in such a way as to prevent rubbing. During this time all sprouts nearer the grafts than 2 feet must be kept pruned off.

FIG. 8.—Completed cleft graft covered with wax.



Only in the case of grafts that have failed to take should sprouts be allowed to grow near the point of grafting. In this case one or two such sprouts may be used for budding, thus enabling the operator later in the season to make a second attempt at propagation.

BUDDING.

Thus far budding has been practiced only by amateurs. More or less experimenting was done the past decade and few propagators



FIG. 7.—Grafted stock wrapped with a plain or waxed cotton band.

found it commercially useful, but with the rapid spread of the idea that only grafted or budded trees should be planted for orchards came a corresponding growth of interest in budding. Several persons investigating independently within the past two years have produced excellent results from carefully selected buds, modifying in several respects the methods usually adopted in budding (figs. 13



FIG. 9.—Completed cleft graft covered with a strong paper bag to protect it from evaporation. This bag should be removed when the scions have made considerable growth.

and 14.) While not sanguine enough to publish results, some experimenters believe that we are soon to witness a decided change in the method of budding, which will displace, especially in nursery propagation, the present unsatisfactory practice of crown grafting. During 1910 less than 20 per cent of the nursery grafts effected successful union, and in a few instances propagators who had formerly secured as high as 50 to 60 per cent of unions were rewarded with less than 10 per cent. The low percentage of "takes," together with the heavy expense of operation in crown grafting, makes it desirable to adopt another method.

To stimulate experiment along this line, at-

tention is called to a few points found useful last year. One worker found that the use of dormant buds upon the present year's growth during July resulted favorably. He adopted the usual method of budding, but made the crosscut at the bottom instead of at the top of the slit. Another recommends chip budding (fig. 15), with bicycle tape¹ for wrapping material. This operator finds it necessary to use buds that are fully dormant, preferably those which have been

¹ Bicycle tape gave very unsatisfactory results in budding operations at the Arlington Experimental Farm in 1912.

kept in cold storage, but if such buds are not available, then use secondary or tertiary buds formed early on the present season's growth. Some propagators recommend plate budding (fig. 16), and exhibit highly satisfactory work done by this method. One propagator working by this method selects stocks 1 to 1½ inches or even larger in diameter and takes buds from stocks, shoots, or branches that are one-half to three-fourths of an inch in diameter. He recommends that the operation be performed as late as possible to get a good flow of sap when the weather is cooler (an important factor); growth for the season is about completed, and the wrapping used may remain on all winter. Prong budding (fig. 17) was highly recommended by the late B. M. Lelong, of California, and is strongly indorsed by a few skillful workers on the Pacific coast. In all these instances the prime requisite appears to be the dormancy of the bud followed by close wrapping and sealing to protect the wound from the air.

Recently E. J. Kraus,¹ of the Oregon Experiment Station, as a result of extensive experiments in budding the walnut, states in substance that the method of budding consists in the combination of the old principles adapted to new subjects and conditions. By this method with good buds, 1-year-old seedlings, and the exercise of ordinary care, 70 to 90 per cent of the buds should take and form satisfactory trees.



FIG. 10.—Modified wedge grafting: *a*, Stock with wedge removed; *b*, wedge to be discarded; *c*, scion with lower end shaped to replace discarded wedge; *d*, scion fitted into stock and wrapped with cotton twine; *e*, completed graft with wax covering.

¹ Circular 16, Oregon Agricultural Experiment Station, 1911, p. 3.

Briefly stated, Kraus's instructions for accomplishing such results in Oregon are as follows:

The best stock was the California black; the hybrids were found to be not dependable; buds of the present season's growth were found to be unsatisfactory for several reasons; plump buds 1 year old were found best. These may be taken from the base of the current year's growth or from scion wood cut during the winter and kept fully dormant. Such bud wood should be placed in moist sand about two weeks before budding is to be done. The T and inverted T methods were found unsatisfactory, and the hinge and flute bud were used. Special care is needed in the wrapping and waxing to see that it is pressed firmly against the wood of the stock and that the air is excluded; tie the buds into place with raffia, then cover with waxed cloth; if budding is done in hot weather it is desirable to tie a paper sack over the bud for protection; in about 10 days remove the wax and this outer protection; about a week later cut the raffia band; use care to see that the raffia is neither left too long on fast-growing stocks or cut before the bud has united firmly.



FIG. 11.—Modified whip grafting: a, Stock prepared to receive scion; b, scion with lower end shaped to fit into stock as prepared; c, scion fitted and held in place by twine wrapping and protected by wax covering.

The following details as to the method of hinge budding and pushing the bud under protection are distinctly different from those given by the older authors:

Making the bud.—About 1 inch above the surface of the soil make a transverse incision about half an inch long, and a similar one about three-fourths of an inch above this. Connect the two with a longitudinal incision. This forms the completed I cut on the stock. It is very desirable to use extra care in making these cuts. The ideal condition is to merely penetrate the bark just to the wood but not to cut into it. The bud, which is rectangular and of exactly the same length as the distance

between the two transverse cuts on the stock, is removed from the bud stick by first making two transverse cuts the proper distance apart to give the correct length to the bud, and then connecting these with two longitudinal cuts about half an inch apart. The bud is then easily removed by gently inserting the back of the knife blade under one corner of the piece of bark and prying up, when it will be found that it will readily part from the bud stick. No wood should be removed with the bud and care should be taken when the bud proper is extra large to avoid pulling the soft wood or core out of it. It may be necessary in such a case to first loosen the bark containing the bud on one side up to the bud proper, then carefully cut this soft core with a knife and

the remainder of the bud piece may be easily removed. As soon as the bud is removed from the bud stick it should be immediately inserted into the stock. This is readily accomplished by first carefully turning back the upper corners of the I-shaped cup, slightly prying them away from the wood, then inserting the base of the bud into the opening, pushing it down until the top and bottom of the bud are flush with the transverse cuts on the stock, and the bud lies smoothly and snugly against the latter. By making the bud force its own passage under the bark of the stock after this manner there is much less exposure to the air than if the sides of the cut are first turned back and the bud then laid in place. The bud is now ready for tying and waxing as explained below.

Starting the bud into growth.—If the budding has been done in June or earlier and the buds are to be started into growth the same year, the trees should be headed off at the time the raffia is removed, about 15 days after the budding. Cut off the stock about $1\frac{1}{2}$ to 2 inches above the bud, allowing the top to remain attached at one side by a small piece of wood or bark. These tops should then be broken over and laid overlapping each other in the row, thus providing shade to the buds and aiding in the carrying off of excess sap and preventing to a considerable degree an excessive sprouting from the root. In about two weeks the scion bud will have started into active growth. The top of the stock should then be removed entirely, close to the bud. In sections subject to high winds the young shoots should be staked. See that all buds and shoots from the stock are taken off, as they are a material drain on the reserve food supply in the stock.

If the budding has been done late in the season so that the trees can not be headed back before August 1, such heading back had best be deferred until the following spring just about the time that growth starts. There is some



FIG. 12.—Stays applied to a top-worked walnut tree to prevent the growing grafts from being blown away or broken off by their own weight. (Photographed by J. B. Neff.)

danger of the buds being killed during the winter or injured by excessive wet weather. It is therefore preferable in such cases to put the buds somewhat higher on the stock than when the trees are to be headed back in June or July. Trees coming from stock headed back about the middle of June to the first week in July will make from 14 to 20 inches' growth the same season and usually mature thoroughly, so there is no danger of killing back during the winter. Such young trees could be put on the market the winter following the budding.

Trees from stock that has been headed back in the spring will make a straight growth of 5 to 7 feet during the season.

WAXES.

The following recipes for waxes are substantially from the several propagators cited:

Beeswax 1 pound, rosin 5 pounds, flaxseed 1 pint, lampblack 1 ounce; melt the mixture. The object is to get a wax that is soft enough to be pliable without running; a little practice will soon show whether the wax needs more or less oil.—*J. B. Neff.*

Rosin 4 parts, beeswax 2 parts, tallow 1 part. Cut the materials up into small pieces, mix well, and boil for several minutes. Dip the hands in linseed oil before using this wax.—*Wright, a Texas grower.*

Linseed oil 1½ pounds, beeswax 1½ pounds, rosin 9 pounds; or, linseed oil 1 pound, beeswax 2 pounds, rosin 9 pounds. Tallow would answer in place of the oil, but the oil is better. Heat over a slow fire until all materials are fully melted and unified, but do not boil.—*R. Wiltz.*

Rosin 5 pounds, beeswax 1 pound, finely pulverized charcoal one-half pound, raw linseed oil 1 gill. Melt the rosin and beeswax over a slow fire, then stir in the charcoal, add the oil, and pour into pans that have been previously oiled with linseed oil so that the wax will not stick.—*G. C. Payne.*

PLANTING, TRAINING, AND PRUNING.

The leading problem with every orchardist is, What are the best varieties to plant? While preferred varieties may be indicated, selection in each instance must depend upon the judgment of the individual. Upon this point some light may be shed by the remark of one of California's foremost students of the walnut. When asked, "What varieties are best for me to plant?" he said: "I do not know. If you will come to my home I will show you what I

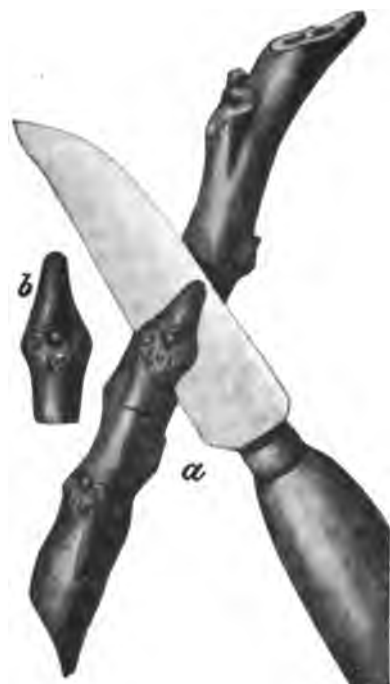


FIG. 13.—Budding by the T, shield, or slip process: *a*, Cutting the bud from the bud stick; *b*, the bud after removal.

have done, give you the whole story, and then you can draw your own conclusions." Those who contemplate planting walnut orchards will do well to visit the successful growers of the district where they contemplate planting. Within tentative boundaries the types that have given and promise to give the most favorable and certain returns are here indicated.

For the southern California region the six blight-resistant varieties suggested by the University of California:¹ Chase, Concord, Eureka, Franquette, Mayette, and Wiltz, though the Franquette is affected by blight in some districts. The Franquette and Mayette have been tried to a limited extent in southern California but so far as reported with rather indifferent results.

For northern California: Concord, Franquette, Mayette, Meylan, Wiltz, and possibly Parisienne and Treyve, though Mr. Hutchinson, the only grower of Treyve, reports that

it is late in coming into bearing and yields light crops—two serious faults. The Eureka is also urged by some observers as especially worthy of trial in this district.

For western Oregon and Washington: Franquette and Mayette are the only varieties yet given extended trial, but Concord, Meylan, Parisienne, Treyve, and Wiltz are well worth general testing in an



FIG. 14.—Steps in the process of T, shield, or slip budding: a, Stock with inverted T-shaped slits in bark prepared to receive bud; b, same with bud being slipped into place; c, bud in place ready to be wrapped; d, bud showing through cut in wrapper when process is complete.

¹ Bulletin 203, California Agricultural Experiment Station.

experimental way. Of Concord, Groner says: "This variety is too late for our environment."

For the Eastern States: Only one variety, the Pomeroy, has been generally disseminated. As a seedling it has been given a thorough trial. It is apparently suited to the climate of the more favorable sections of the Eastern States and will undoubtedly yield a more uniform product and better results when worked upon the eastern black walnut. The Nebo and Rush varieties, recent introductions which promise well, are being worked on native stock, and are the only eastern varieties of which grafted trees are offered for sale at present, though others will probably be offered in 1913. A few other varieties give promise of meeting local requirements for a hardy, productive, marketable nut of fair quality, notably Cumberland, Holden, Milbank, Mount, and Sinclair. Trees of the Bijou type have proved in several instances to be hardy and good croppers, but the nut, though suitable for home use, is not considered of commercial importance. It is expected that experiments under way will in a short time demonstrate the fitness of some of the harder European strains, particularly when top-worked upon the native black walnut.



FIG. 15.—Steps in the process of chip budding: *a*, Bud stick with bud partly removed; *b*, stock with bud removed and discarded, ready to receive new bud; *c*, new chip bud from bud stick in place on stock; *d*, bud wrapped as it appears when operation is complete.

POLLINATION.

Before deciding what varieties to plant, ample pollination must be assured, as otherwise generous crops can not be produced. The walnut normally produces two kinds of blossoms: The staminate, commonly spoken of as the catkins, and the pistillate, usually called nutlets (fig. 18, *a* and *b*). This arrangement of the sex organs on two separate parts of the plant, together with the peculiar structure of the flower, necessitates the employment of an outside agency—the wind—to insure pollination. The staminate blossoms, when open, are much expanded (fig. 19, *a*) and heavily charged with dustlike pollen released from little sacs (the anthers) and blown upon the stigmas of the pistils (fig. 18, *d*), thereby effecting fertilization. Not infre-

quently these two kinds of blossoms (staminate and pistillate) do not mature at the same time upon the same tree, or one or the other of them is infertile because of imperfect development; such tree, if by itself, is unproductive. The Los Angeles or Mission walnut, when planted in the northwestern Pacific region, persistently fails to fruit for one or other of these reasons, though occasionally failure is chargeable to late frosts.

To insure complete fertilization care should be exercised in the selection of varieties. Where little definite information about pollination and fertilization is available it is safe to plant two or more varieties which blossom at the same time. In some instances of shy bearing it may be desirable to introduce a variety rich in pollen, regardless of the character of its nuts, in order to amply fertilize the blossoms of the more valuable varieties. To insure effective pollination

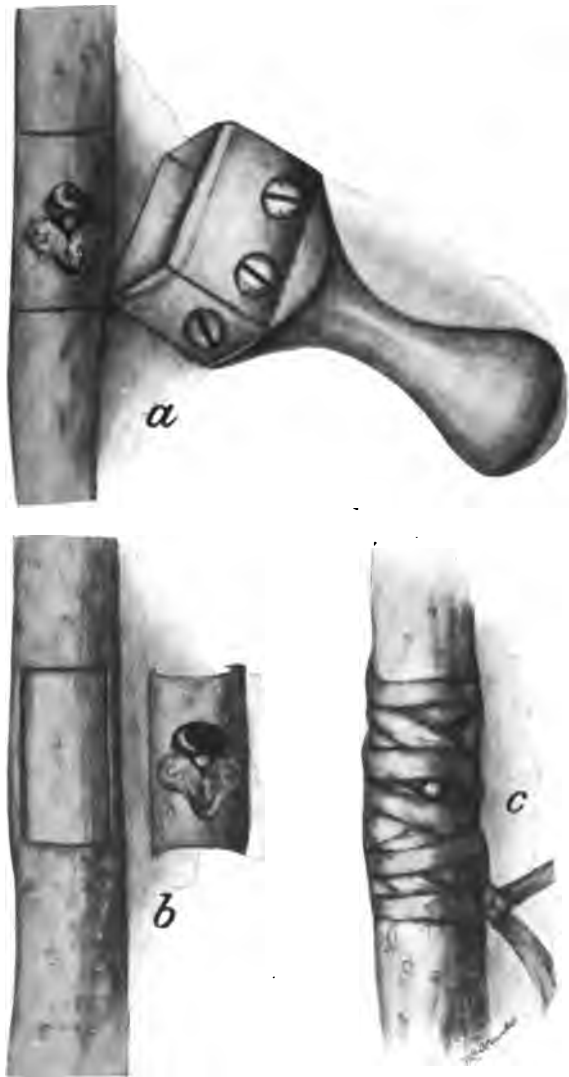


FIG. 13.—Plate or partial ring budding: *a*, Bud stick showing bud marked for removal by special tool used for the purpose; *b*, stock with patch of bark removed and discarded ready to receive new bud; *c*, new bud in place and wrapped with raffia, completing the process.

one tree in seven when planted in quincunx and one in six when planted in squares is deemed sufficient, except possibly where prevailing winds are strong and persistent from one direction. Many

American growers are of the opinion that future orchardists will make provision for insuring a high percentage of fertilization by mixing varieties. Until ample investigation has been made it is safe to plant only varieties of known value as pollinizers, leaving the work of testing varieties not so well known to the State or Nation, except as the enthusiastic amateur finds it advantageous to make trials of promising new varieties.

So far as recorded by American growers only two varieties, the Santa Barbara and the Franquette, have been planted in pure stands of any considerable area. With these two varieties crop shortage appears not to be due to insufficient pollination, but no definite experiments have been performed to ascertain whether better results might be obtained if opportunity for cross-pollination were afforded. California growers after many years of experience con-

sider the crop better in those orchards where more than one variety is grown. In the case of the Santa Barbara the type, vigor, and individuality of the trees vary as widely as several different varieties ordinarily do, insuring nearly as active cross-pollination. Briefly, then, it may be stated that while good crops may be secured from tracts planted to single varieties, especially if free blossoming with catkins and nutlets at the same time, progressive growers advise mixed



FIG. 17.—First and last steps in the process of prong budding or prong grafting.

plantings of two or three varieties of similar merit, keeping in view that they should be equally well adapted to the location and blossom at the same time in order to insure effective pollination.

PLANTING.

The walnut is planted as early in spring as the soil permits, care being exercised to avoid puddling when the ground is too wet. The distance between trees varies from 40 to 60 feet each way, requiring 12 to 27 trees to the acre. Some growers recommend planting trees in the center of the squares made by the first alignment, such trees to be removed as soon as those in the regular rows require the space for their development. It is asserted that the increase of product,

if grafted trees are planted, will pay a liberal profit upon the additional cost involved in the purchase and planting of the extra trees.



FIG. 18.—Young shoot of Persian walnut with a piece of the previous year's growth, showing staminate and pistillate flowers in situ: *a*, Pistillate flowers; *b*, the same enlarged; *c*, staminate flowers; *d*, portion of same enlarged.

Only deep, rich, well-watered soil should be used for growing a walnut orchard, and the filler trees should be removed as soon as the regular trees are 16 to 20 years old.

Formerly much difference of opinion existed as to the age at which trees should be transplanted from the nursery, but recent practice favors 1-year-old trees that have been grafted on stocks 1 or 2 years old. Such trees average $4\frac{1}{2}$ to 6 feet in height and an inch, more or less, in diameter 1 foot above the union of the stock and scion and may be taken from the nursery with a larger root system than when older. Since trees at this age will be unbranched, the grower will be able to

adjust the branches that form the head to much greater advantage than if transplanting is delayed until after branches have formed in the nursery. The walnut does not suffer so much from malformed heads as some other deciduous orchard trees, but a well-formed head is desirable if vigorous and long-lived trees are to be grown.

The details of planting are quite the same as for other orchard trees. Keep the roots from air as much as possible between nursery and orchard. Prune off all bruised and broken roots with



FIG. 19.—Sexual organs of the Persian walnut: *a*, Matured catkin; *b*, fertilized, unblighted nutlets; *c*, blighted nutlets of the same age.

a clean, smooth, oblique cut. If possible to obtain trees from the nursery in the autumn preceding planting, root pruning may then be done advantageously before the trees are heeled in, and the wounds will be callused before planting time. The growth of the new rootlets can then proceed more quickly at the opening of the season. In recent years much discussion has arisen over the importance of the taproot. It is safe to say that healthy vigorous trees with a good supply of lateral roots and a short piece of taproot will make as good development as one with a longer taproot. The removal of the taproot is not

prohibitive of the success of transplanted trees, especially if they are not more than 2 years of age.

TRAINING.

The subsequent treatment of the young tree will depend upon the end to be attained. If the head is to be formed high the tree must not be cut back, but must be supported in an erect position by a tall, strong stake 2 by 3 inches in cross section and 8 feet long (fig. 20).

If it is decided to form a low head the top may be cut back to 4 or 5 feet and a short stake driven to hold the stock upright until the branches are well formed and the trunk of sufficient strength to support the head. When the young branches have issued a few inches the trees should be examined and only those shoots permitted to grow that will help to form a strong, symmetrical head. The young main branches allowed to grow should issue 9 to 12 inches apart on the trunk and be so supported, if need be, that they will grow obliquely upward. After the 3 or 4 main branches have become fixed in the desired positions little remains to be done in training or pruning except to remove the sprawling growth from the lower



Fig. 20.--Young walnut tree staked and tied—a general practice with high-headed trees in Oregon.

side of the outspreading branches and such wood as threatens to rub, interlace, or unduly crowd (fig. 21).

In sections where the summer heat is not too intense the walnut should be pruned to present an open, spreading head, facilitating the formation of bearing wood throughout the top rather than on the outer portions, as is usual with dense heads. Where the summer temperature rises to 110° or higher it is necessary to train close or dense heads to protect the nuts from sunburn, which darkens the kernel and lessens the market value.

It was formerly the practice to head the trees 6 to 9 feet high, but now many start the heads at 4 to 5 feet. In pruning and training during the first few years this lowness of branching is of considerable advantage. The fact that the walnut tree is wide spreading has led many to suppose it necessary to head high in order to facilitate tillage and harvesting beneath the branches. By proper training the



FIG. 21.—Unpruned Persian walnut tree with an abundance of trailers.

head may be started low and the branches still be kept well out of the way. (See frontispiece.)

Low spreading branches and close heads favor blight, while high open heads permit free circulation of air and penetration of sunlight which are unfavorable to the development of blight. Low heading at 4 to 5 feet does not necessarily imply that the tops shall be low. They may be quite as high and open as though the heads were started at 7 to 9 feet from the ground. In the first instance pruning, forming the head, and training the branches can be performed more effectively, with a sav-

ing of both time and labor. The importance of the proper structure of the head does not usually appear until heavily laden mature trees are wrecked by an autumn storm.

Little pruning and less training has been done in the past, but more attention is now given to these matters. Growers are studying the young trees in newly planted orchards and are debating how to stimulate growth, increase the yield, and lessen the effects of blight

by judicious pruning. Specific treatments are being tested, such as thinning out the centers of the tops, lifting the outspreading portion of the head by pruning off the lower limbs, and in some instances removing lateral branches, all insuring the tree more light and air and a better distribution of bearing wood.

As the area of cultivation becomes extended and the varieties under cultivation are augmented by the addition of types developed to meet local conditions, which are practically numberless, it is certain that extended and varied practices in pruning and training will be evolved.

PRUNING.

The walnut actually requires very little pruning. Root pruning and cutting back attendant upon planting have been referred to under training; such other pruning as is found necessary or desirable to keep the tree in form for the best results should be done during the resting period and at least two or three weeks before the starting of the sap in spring, so as to permit the wounds to become dry and to prevent bleeding and a tardy healing of the wound. If close attention is accorded the tree in all matters pertaining to its proper training it will rarely be found necessary to remove other than small branches. Should it become imperative through accident, oversight, or other contingency to take off a large branch, care should be exercised to prevent the splitting or tearing of the part remaining.

The removal of a large limb may be best effected by cutting it off in sections. In order to prevent back splitting, bruising, or crushing make a deep saw cut on the under side of the limb some distance out, then upon cutting into it from the upper side a few inches farther out the limb will break short off. Another operation will dispose of the stub and leave a clean-cut surface close to the main body. In any event make the final cut so that no projecting stub is left.

Upon the removal of any branch over an inch in diameter cover the wounded surface with quick-drying adhesive paint, such as a good quality of white lead and linseed oil, in order to keep the surface dry and prevent the attacks of fungi. This paint will be of greater efficacy if the wound is first brushed with a strong solution of one part of copper sulphate to three parts of water. From time to time go over the orchard with a paint pot and brush and renew the covering on these wounds to prevent fungi from obtaining a foothold.

During the first few years of growth of the walnut it is prone to develop many drooping shoots from the lower branches. These are often used for bud or scion wood, but the practice is to be deprecated. Such shoots rarely if ever bear on the parent tree and it is possible

that the continued use of such wood may induce a habit of drooping growth and transmit barrenness. Until investigation definitely disproves the idea it is safe to avoid such practice.

CULTIVATION OF THE ORCHARD.

Clean tillage is the almost universal practice, except as to cover and truck crops. Cover crops are coming into general use for blanket and humus purposes and truck crops are grown among young trees. In the large orchards of southern California where clean tillage has been practiced 15 or 20 years the soils are becoming less tractable because although tons of leaves fall upon the ground in the autumn only a small proportion of them become incorporated with the soil. They blow away from the smooth surface of the orchard floor into



FIG. 22.—A harrow used by California cultivators to produce the dust mulch much employed in the groves of that State.

ditches, fence rows, and hedges and are largely lost to the orchard area. Cover crops are useful to hold these leaves in place as well as to furnish humus and to prevent wash from winter rains. With cover crops, the first operation in the spring is to plow under such crops to a depth of

6 or 7 inches. This operation may be followed at once with a spike or spring tooth harrow and then with a roller or clod masher if the condition of the soil demands it. This first or spring preparation of the soil should be followed by frequent scarifyings, once every 10 days or 2 weeks, to kill weeds and to convert the surface into a dust mulch to better conserve the water supply. These operations are usually performed by riding cultivators with broad-winged shovels or with an implement known in California as a scarifier, having broad blades set obliquely to the line of draft, each one partly overlapping the course of the one ahead of it (fig. 22). From years of experience many of the large California growers in districts where the annual rainfall is over 24 inches are convinced that it is better to maintain a thorough dust mulch throughout the growing season than to irrigate, though frequently one application of water about two weeks before the nuts begin to fall is of service in causing them to separate more readily from the hulls.

IRRIGATION.

The details of irrigation are much the same as for orchards of other deciduous trees. The site, soil, location, and season are in each instance governing factors. Present irrigation of the walnut is confined to the section of California south of Ventura and to the interior valleys. The furrow system is generally used in orchards where the soil is heavy and the basin system where the soils are light. In districts where a mild climate will permit and the soil is deep and retentive, winter irrigation may be practiced with decided benefit.¹ Where the rainfall is 17 to 23 inches two applications of water are advised, one in February and one in May. In very dry seasons a third application before harvesting is desirable to prevent the hulls clinging to the shells. Possibly the machine huller will be more economical than an application of water.

COVER CROPS.

Some years ago several growers in southern California noted that the nuts from the older orchards were averaging smaller, one year with another, than those from young trees. Experiments with a few trees and in one instance with a large orchard, that of John F. More, of Goleta, showed frequent applications of cover crops to be of decided benefit to old orchards. It is becoming apparent to owners that provision must be made to supply plant food to the soil if the trees are to maintain the crop standard in quality and quantity.

The selection of a cover crop will depend upon the location. Mr. More found barley and volunteer plants sufficient; others find it desirable to use some leguminous plant to obtain nitrogen. In the Pacific Northwest vetches will probably give the best returns. If the land is well supplied with nitrogen and needs only humus and a protection from beating rains or wash, then any of the winter-growing crops like mustard, wheat, rye, or winter oats will serve the purpose. In parts of California vetches, winter and hairy, fenu-greek, Canada field peas, bur clover, sweet clover, and volunteer plants such as alfalfa, mustard, and others are available.

As to the expense and management of cover crops the following by Samuel Fortier² is especially pertinent:

In the walnut groves of Orange County, Cal., bur clover is sown in the fall, given one or two irrigations during the winter if the rainfall is below the normal, and plowed under in April.

The cost of such cover crops as peas, vetch, or clover includes the seed, the labor of sowing it, the water, and the time required to apply it. These items, according to Dr. S. S. Twombly, of Fullerton, Cal., amount to \$2.50 to \$3.25 per acre. Twenty tons per acre of green material is perhaps an average crop. In this tonnage there would be about 160 pounds of nitrogen, which at 20 cents per pound represents a value of \$32 per acre for a cover crop like vetch.

¹ Irrigation of Orchards. Farmers' Bulletin 404, U. S. Dept. of Agriculture. 1910.

² Idem, p. 35.

FERTILIZERS.

The question of fertilizers for the walnut orchard is one that has not yet attracted wide attention. In recent years owners of old orchards have found some form of manure necessary to insure thrifty growth and a substantial crop. While cover crops are desirable and serve to ameliorate and improve the soil and increase its fertility, something more appears to be needed in soils long covered with bearing orchards.

In France, where the problem is of long standing, Fallot cites Rouault's formula¹ as approximating its own calculations for a chemical fertilizer suitable for walnut culture, as follows:

Nitrate of soda containing 15 per cent of nitrogen, 78 pounds; superphosphate containing 12 per cent of phosphoric acid, 16 pounds; and chlorid of potassium containing 48 per cent of potash, 6 pounds; total, 100 pounds.

In the article cited M. Rouault¹ says:

Now, are not these three substances most appropriate to the soils and to the needs of vegetation? Would it not be an advantage also to adopt a manure mixed of farm manure and chemical substances in a manner to give it a composition approaching that which I have indicated?

After making numerous analyses of the walnut and an extended study of the soils of France, Fallot² states:

The walnut is rich in nitrogen and contains considerable proportions of phosphoric acid and potash. In regions where intensive culture has been adopted it will be an advantage to use fertilizers containing nitrogen, phosphorus, and potash in proportions varying with the needs of the tree; that is, depending on the quantities of fertilizing elements which the tree removes from the soil and does not restore. As regards the walnut, the fruit alone takes out these elements; one can neglect the small proportions remaining in the wood, and the leaves in general return to the soil either directly or after having been utilized as litter.

While Fallot says that the French walnut is especially rich in nitrogen and makes the composition of the whole nut nitrogen 2.66 pounds, phosphoric acid 0.75 pound, potassium 0.79 pound, analyses by G. E. Colby, of the University of California, give nitrogen 0.54 pound, phosphoric acid 0.15 pound, potassium 0.82 pound and show it rich in potash rather than in nitrogen.

The problem of fertilizers is complex. It is no longer held to be simply a matter of returning to the soil what the crop takes out, or of supplying those substances that analysis shows to be wanting in the soil. A half score of other factors as important as these enter into the problem of how to feed the orchard. A knowledge of the composition of soil and crop is valuable, and even more so

¹ Rouault, M. F. *Le noyer, recherches destinées à guider dans la composition des engrais qu'on lui destine.* Grenoble, 1891. [Cited by B. Fallot.]

² Fallot, B. *Culture du noyer.* *Journal d'Agriculture Pratique*, t. 2, 1898, pp. 348-349.

are data pertaining to the physical conditions of the soil, its texture, component parts, aeration, drainage, humus and water content, biological factors, and the health, vigor, and yield of the plants growing thereon.

Nothing short of practical trials of fertilizer materials will determine just what the needs of an orchard are. While cover crops perform excellent service in several ways, they must be supplemented in the older orchards with phosphoric acid, potassium, and possibly lime. As a result of extended work upon California soils, Dr. Hilgard advises that it will be safest to begin with phosphate; if unsatisfactory, apply nitrogen; and if anything further is needed, use potash.

Each orchardist must solve his own problem by varying the treatment to meet the different soil conditions. Granting that the soil conditions are of average adaptability to the walnut, specific requirements are a generous supply of humus, available nitrogen, phosphoric acid, and potassium, with ample aeration and biological activity. Cover crops supplemented by mineral fertilizers are usually most economical. Advice may be sought of the chemist of the State experiment station, and it is desirable to consult the experience and studies of station experts upon the various phases of orcharding.

As a series of first trials, it is suggested that one part of the orchard to include its various soil types be planted with a cover crop of legumes and another part with nonlegumes. On parts of each of these areas soon after growth has started use different minerals or mixtures, preferably plowed under or disked in with the cover crop. For example, about each of several trees, say from 12 to 20 years of age, use 5 to 15 pounds of superphosphate and about each of several others twice the amount. On another part of each cover crop area, leaving at least two trees between the different trial groups, give several more trees twice as much superphosphate. About trees of another group put 4 to 12 pounds of sulphate of potassium and about the trees in yet another group 8 to 20 pounds. To other groups supply a mixture of the two substances in the above proportions. Such tests varied by years or pursued more than one year should afford results of much value to the orchardist.

Ralph McNees, of Whittier, Cal., in a letter reporting his experience, says:

My grove is located upon very deep, rich, dark clay soil. Until recently I have been able to secure enough stable manure to give my orchard a good dressing each year, which, with a crop of bur clover to turn under each year, has kept up the fertility of the soil and supplied the necessary humus without having to resort to the use of chemical fertilizers. Recently it has become difficult to secure sufficient stable manure, and I have depended upon the nitrogen-gathering cover crop to supply the necessary nitrogen and to bring up the potash with which our soils appear to be well supplied. In addition, I have added about

one-half ton of superphosphate per acre. At the same time I have used all the stable manure that I could readily procure. My crop varies but little from year to year, and orchards that were alternate bearers before are now under this treatment annual bearers. My aim with this treatment is to keep the tree vigorous and making good annual growth; this insures regular bearing and good crops. A fellow grower has accomplished the same or even better results by growing an annual crop of vetch, and after irrigating it by the furrow system whenever necessary to insure a full crop plows it under in July. Of course the character of the soil, the number and age of trees per acre, cultivation, and irrigation will all tend to influence the yield. But two conditions are evident in the vetch treatment: First, an increased amount of available nitrogen; second, a largely increased humus content; both of which are important factors in walnut growing.

INTERCROPS.

Should an intercrop like beans be grown, a not uncommon practice in parts of southern California while the trees are young, returns from such crop may be expected to net \$20 to \$50 per acre, while the straw and chaff are returned to the soil as fertilizer. In some sections tomatoes, cabbage, squash, melons, and similar crops are grown among the trees during the first few years. Potatoes, beets, and similar root crops attract gophers, which eat the young roots of the trees and do much damage. The returns from intercrops vary, but approximate the returns from the bean crop under like conditions. Under exceptional local or seasonal conditions the income from the melon or tomato crop may be materially larger, and in an exceptionally poor year the returns from the intercrop may be nothing at all.

It must be kept in mind that the intercrop is taken off merely as a loan upon soil resources that properly belong to the orchard and that if too long or intensively continued the practice may work to the disadvantage of the trees. If the intercrop must be grown restitution may be made by cover crops and fertilizers.

FILLERS.

Fillers are sometimes used instead of intercrops to occupy the soil more completely during the earlier years. The practice involves extra outlay, but may yield a corresponding revenue. The filler crop varies with the district. In California it may be peaches, plums, prunes, oranges, or lemons; in Oregon, prunes, early-bearing apples, or cherries. It is seriously debatable whether on the whole it is not better to avoid the use of fillers entirely, though much depends upon the individuality of the orchardist. Within bounds fillers may be employed to advantage, but if allowed to prejudice the normal development of the main crop they become an injury not compensated by the income which induces its employment. Not only do fillers require the care and attention of the cultivator at the same time that they are needed by the main crop, but they draw heavily upon the food and water resources of the soil as they become older. With the owner's

interest temporarily occupied with the crop that brings the earlier returns it frequently occurs that he overlooks the fact that the main crop, though yielding little or no revenue, requires to be supplied with ample food, water, sunlight, and air, all of which are being taken from them by the activities of the filler crop. If fillers must be utilized let it not be forgotten that additional food and water supplies must be provided if the principal and the secondary crop are both to succeed.

PESTS AND DISEASES.

BLIGHT.

The walnut serves as host to several insects and a few fungi, but the records indicate that few of them are serious foes to the tree or its fruit. Among those that do considerable damage year by year, blight or bacteriosis is most destructive. The bacterium causing this disease was discovered and named *Pseudomonas juglandis* by Newton B. Pierce, formerly of the Department of Agriculture, while conducting research investigations in plant pathology in southern California in 1896. For a few years prior to that date, and even since its discovery, this organism had been a menace to the walnut industry, particularly of this southern district. At present, evidence of the blight is found in nearly all localities of the Pacific coast, where the walnut is cultivated commercially. It has also appeared in several parts of New Zealand with disastrous results, but is not elsewhere reported.

The damage is manifest chiefly in the young shoots and nuts. The affected shoots wilt, turn black, and die back from an inch to a foot or more (usually 3 to 6 or 8 inches). On young and rapidly growing trees the injury is often very serious, though as yet no record has been made of a tree being killed by blight. The injury to the nuts occurs about blossoming time, when there is little development, and the very small nuts fall from the tree. Those attacked at any subsequent date may either fall or remain until the tree is poled, depending on the virulence of the attack. Poling is performed by shaking or striking the limbs with a long pole having an iron hook at the end.

The disease attacks the hull from the outside (fig. 19, *c*) and gradually passes inward, destroying more or less of the shell—though often only discoloring it, in which case the nut remains on the tree—and later shriveling and blackening a part or all of the kernel. Blighted nuts usually fall prematurely, but sometimes remain on the trees to the end of the season. Figure 19, *b*, illustrates a group of unblighted young nuts of the same age as figure 19, *c*.

Blight appears with the first vegetative activity in spring and develops rapidly in moist warm weather. The period of most destructive activity usually lasts not more than 10 days. In 1910, at

Saticoy, where fog prevails to a far greater extent than at Santa Paula, the orchards were much less seriously affected.¹ Saticoy is nearer the ocean than Santa Paula, and perhaps the temperature during early growth was more favorable.

That blight has become a disturbing factor in the crop output of the California walnut orchards is evidenced by the fact that one firm with an established bearing orchard of 500 acres has removed the trees from 65 acres and is seriously contemplating the clearing of 75 to 100 acres more because the blight is particularly destructive in that part of the orchard.

Well-known orchardists in charge of large properties assert that the loss from blight in 1910 approximated one-tenth of the crop. The fruit of some trees was injured to the extent of 10 per cent, of others 60 per cent, while some were but slightly injured. The total loss, in round numbers, to the industry must have been over a quarter of a million dollars.

Both National and State Governments have realized for some years that the problem of combating the blight is serious, and each has conducted in its own way very complete investigations covering the subjects of remedies, especially the application of sprays. The investigators employed by both the Nation and the State are agreed that spraying offers no sure means of combating blight. Extended but incomplete observations made over widely separated areas indicate the possibility of partly overcoming the effects of blight by the use of fertilizers which stimulate the trees to an increased yield, and also that irrigation promises similar results.² Definite results from more extensive and completed experiments are awaited with much interest.

The latest findings relative to blight are by the University of California experiment station, from whose Bulletin 203 the following excerpts are taken:

The ultimate solution of the blight problem appears to be in the growing of walnuts immune to the blight, desirable types of which are already in existence. Much work is being done at the Whittier laboratory in this direction. This involves the growing of grafted rather than seedling trees, and thus opportunity is given for choice regarding both the root and the top of the tree. Each is of great importance. Extensive plantings have been made at the laboratory of nuts of various kinds and sources for the production of root stocks. These represent several species of walnuts and also hybrids between different species. Experience has already shown that in the native California black walnut we have a more hardy root than that of the English walnut, one that is more capable of flourishing under unfavorable conditions and one with a much wider range of soil. The native walnut varies, however, in individual

¹ Observation of C. C. Teague, president of the Southern California Walnut Growers' Association.

² Bulletin 203, California Agricultural Experiment Station.

trees almost as much as the cultivated species, so that there is room for careful selection and discrimination in growing a root stock. The California walnut is also divided more or less distinctly into two separate species. It may be classed as the southern California and northern California types. The tree which grows wild in the southern part of the State has its favorite habitat upon dry, somewhat elevated hillsides, with occasional trees in the valleys at the foot of these hills. It is distinctly a hillside rather than a valley tree, however. The tree itself has quite a shrubby rather than a treelike form, and even in large specimens grown on good soil with abundant water the tendency is still toward abundant branching rather than the formation of a tall, clean trunk. * * *

The origin of the northern California walnut is much in doubt. While this tree is one of the commonest grown for shade and ornament about many of the towns in central and northern California, yet there are only a very few places where there is any indication of the tree having been indigenous. Considerable attention has been given to this interesting question, and we have found but three locations where the walnut trees go back beyond the knowledge of any white person. These are (1) near Walnut Creek, Contra Costa County; (2) Walnut Grove, Sacramento County; (3) a point in the mountains of Napa County northeast of Napa City, near the top of the west slope of the so-called "Wooden Valley." In each of these places, and at no other which we can find, there were large, old black walnut trees growing at the time of the first white settlement. These primeval trees do not appear to have been indigenous to the localities where they are found, but the question of their origin is an extremely obscure one. Morphological and field studies are being made by Mr. Ramsey upon this subject. The northern tree shows a decided preference for a moist valley soil in the vicinity of streams rather than that of the south for growing on dry hillsides.

Both the northern and southern California walnuts have been found satisfactory as a root stock for the English, but we have as yet no sufficient comparison between them to judge finally as to which is the better. Such comparisons are now being made by this division by grafting English walnuts on various roots and planting them in various soils. The possibility of using for roots some of the not uncommon hybrids between the California black, American black, and English walnuts is also receiving much attention, on account of the extremely vigorous growth of these trees. Selected walnuts from all over the State as well as from other parts of the country have been planted at Whittier, and a very interesting nursery is in process of development.

The selection of a strain or variety of English walnut possessing immunity to the blight as well as desirable commercial qualities is receiving much attention. Immunity to this disease is not obtained entirely by actual resistance, but in many cases by simply escaping the worst infection period, i. e., the moist weather of early spring. Most of the immune trees are such as come out rather late in the spring, thus escaping rather than resisting the blight. Several of the ordinary French walnuts, such as the Franquette and Mayette, have this quality of lateness in an extreme degree, but this involves the question of the time of harvest in the fall, an extremely late crop not being desirable in California. The most promising trees found thus far are local seedlings of foreign varieties which develop somewhat later than our ordinary seedlings, but not so late as the French varieties mentioned. A number have been found which seem to justify their planting as blight immune. Among these we may mention varieties which have received the names Eureka, Concord, Chase, and San Jose, as well as the Franquette and Mayette mentioned above. All of these and many other varieties are being grown by this division and their value

carefully tested for various portions of the State. We are now in a position to supply scions of all the important walnut varieties, as well as a limited number of nursery trees of some.

One very imperative phase of this matter has been the question as to the fate of the present existing plantings, consisting of many thousand acres of fine, large, thrifty trees, very satisfactory in every way except for the occasional loss of a considerable part of the crop through their susceptibility to the disease. Many of these orchards are extremely profitable even under present conditions, and it is evident that by increased attention to soil fertilization their productiveness can be maintained in a very satisfactory degree in spite of the disease.

One means of handling large trees which are extremely susceptible to blight is by top grafting them to the more immune kinds. The methods of doing this have received the consideration of this division, and much work has been done along this line. During 1908 and 1909 a considerable number of large trees were top-grafted, both by the station and by individual growers, with decided success. Experience elsewhere, particularly in the central part of the State where many large native walnuts have been grafted to the English variety, has shown that with reasonable success a new top equal to the original one can be put on a large tree in four years. In orchard work the most rational practice appears to be the picking out and working over of the trees most susceptible to blight each year until finally the whole orchard has been changed. In this way there is no marked loss from cutting off the trees in any one season.

Another method of working over an old orchard consists in intersetting with nursery trees of the California black walnut. It is more practical to plant the young trees rather than the nuts in the orchard. The object of this method is to grow the black walnut trees up to 3 or 4 years old and then graft them in the top to the desired variety. If the ground is closely shaded by old trees, they should be thinned enough to give the young black walnuts a chance to grow. This thinning can be done in most of our older orchards without any disadvantage, as in most of them the trees are already too thick. The young grafted trees will come into bearing early, and it is possible by this plan to have a new orchard well started by the time it is necessary to cut out the old trees. The advantage of a tree having the black walnut trunk as well as root is a very considerable one, owing to the susceptibility of the English walnut trunk to sunburn.

The extensive work by the University investigators entitles their views to great weight and those contemplating the planting of walnuts, particularly upon the Pacific coast, will do well to give them careful consideration.

SUNBURN AND PERFORATION.

The damage resulting from sunburn and "perforation" is occasionally serious enough to affect the value of the crop slightly. Sunburn blackens both shell and kernel, thus injuring the sale of the product. Perforation is denoted by the failure of the shell to fully develop or fill out. Sometimes the injury is in the nature of small openings through the shell; or, more frequently, very thin places. Both troubles apparently are due to unfavorable physical conditions.¹

¹ A fuller discussion of sunburn and perforation will be found in Bulletin 218 of the California Agricultural Experiment Station.

INSECTS.

Occasionally other pests attack the walnut tree or its fruit, but no considerable damage has been reported. In a few instances the walnut aphid has caused slight damage. Other insects that attack the walnut are borers, which work in the trunks of the trees, several species of Lepidoptera, which feed upon the foliage in the larval or caterpillar stage, and the nut weevils, which feed upon the fruit and in some cases on the terminal twigs. Growers encountering insect pests should send specimens and damaged parts of the tree to the Bureau of Entomology, United States Department of Agriculture, Washington, D. C., with a request for information as to the ways and means for combating them.

HARVESTING THE CROP AND PREPARING IT FOR MARKET.

HARVESTING.

The most important phase of harvesting the walnut crop is to prevent the nuts from becoming stained. The market demands that the nuts be a clean, bright-yellowish hue. This requirement may be met in two ways: (1) By care in harvesting to prevent the shells from being soiled with dirt, stained with dye from the hull, or discolored by rains or strong sunlight; (2) by bleaching after being cured.

The outer hull of the Persian walnut ordinarily breaks along irregular lines when mature and permits the nut to fall free to the ground. During dry seasons part of the crop fails to do this or to fall from the tree at all until outside force is applied, usually in the form of poling or shaking. In normal years it is necessary to pole tardily maturing nuts to keep the harvesting period within reasonable limits. Such polings usually also require hulling.

By extreme care in harvesting it is possible to escape the need of bleaching. The natural color of most varieties if fully preserved is sufficiently light to meet the demands of all but the most fastidious purchasers. Let the grower exercise the following precautions: So far as possible gather the nuts just as the hulls open to free them. Allow none to remain long exposed to direct sunlight, rain, or dew, or in contact with the soil, or attached to parts of the broken hull. Let freshly gathered nuts remain for only the shortest time possible in picking boxes, sacks, or other receptacles before subjecting them to the cleaning process. Care must be taken that the nuts are not kept too long in water, as such treatment is liable to partly unseal them. A spray of water playing over a slatted revolving cylinder fully serves the purpose. Twelve to fifteen minutes' active rolling and rubbing is ample to remove soil particles and the hull fiber from the nuts. Then remove the nuts to slatted trays 3 by 6 feet and 3 to

6 inches deep. If the sunlight is intense the trays are placed in a shaded area, as under partially defoliated trees or light screens, where a current of air rapidly absorbs the excess water of the cleansing bath. If the rays of a declining sun are not too hot, the trays are spread on the ground (fig. 23) or on low horses in an open space. Prolonged exposure to a hot sun discolors the shells and sets oil free, which hastens rancidity when the nuts are afterwards stored. Should fall rains attend harvesting operations, place the trays in an artificial dryer where a current of moderately warm dry air may be passed over the nuts for a few hours.



FIG. 23.—Screening and curing Persian walnuts at Anaheim, Cal.

CURING.

After being subjected to this preliminary drying process 10 or 12 hours in the case of the dryer and 3 to 5 days when exposed to the open air the trays of nuts are stacked in tiers 4 to 6 feet high for a week or 10 days, during which the nuts cure, or they may be placed in bins which permit free circulation of air, and should receive frequent turnings. After being fully cured they are graded by passing them over an oscillating inclined plane of wire screen or through an inclined cylinder of the same material, the slightly oblique mesh of which varies from 1 inch to $1\frac{1}{4}$ inches square. With either apparatus the motion is slow, not more than 10 or 12 revolutions of the cylinder per minute or a corresponding number of oscillations of the plane.

HULLING.

Nuts which fail to free themselves from the shell at the time of falling from the tree (called "sticktight") are hulled by hand or put through a machine similar to a corn sheller (fig. 24). For a large quantity the machine method is quicker and cheaper than the hand method. Sticktights are usually due to want of water just prior to ripening. In dry seasons, where possible, a moderate application of water should be given the trees just before the hulls complete their growth. This treatment promotes plumpness of the hulls, which in consequence separate freely from the nuts.



FIG. 24.—Hulling and sorting Perslan walnuts near Santa Barbara, Cal. The nuts travel on endless belts directly from these operations to the drying trays.

ASSORTING.

Having passed the grader, which separates them into two grades, the nuts are next more or less closely hand picked. This assorting operation removes ill-formed, discolored, sunburned, and blighted nuts, and those with broken or perforated shells. In some instances, especially when the crop is wholly prepared at home, the hand picking is done while the nuts are passing over the grader. In the smaller processing plants assorting, generally performed according to a very liberal view of what constitutes standard grades, is done at any stage from grading to sacking as convenience suggests.

PROCESSING.

When commercially considered the southern California crop is usually processed, because under present demands for a bleached

nut this operation offers the easiest, cheapest, and most expeditious means of handling the crop. Processing is responsible for a number of practices that are distinctly local, such as gathering the nuts at less frequent intervals than where processing is not practiced, and grading, bleaching, assorting, sacking, and selling in a specially equipped central plant on a basis determined by representatives of both grower and dealer. When the nuts are sufficiently cured at the orchard they are sacked and taken to the processing plant at or near the shipping point, where they are received and weighed, the grower being given a receipt for each lot as delivered.

To secure a uniform product the selling associations issue instructions to the growers covering details of the various harvesting operations. As the associations are composed of the growers as stockholders it amounts to the issuance by the growers of a set of rules for their own guidance in cooperative effort. The following instructions, issued by the Los Nietos and Ranchito Walnut Growers' Association, of Rivera, Cal., are representative of the action taken by such organizations in southern California:

ASSOCIATION INSTRUCTIONS.

Picking.—The nuts should be picked up as soon as practicable and not allowed to lie on the ground for any great length of time. The sun or fog will injure the meat of the nut or mar the appearance of the shell. Especially will this be the case where the outer hull adheres to the nut after it has fallen from the tree. The nuts should not be poled from the tree before fully ripe. A pole with an iron hook at one end will suffice to loosen the ripe nuts. Place the hook over the limb of the tree and suddenly jerk the pole; this will do the work.

Cleaning.—The nuts should not remain in the picking sacks for any length of time; if they do both the meat and shells are liable to become moldy, thereby injuring the quality and appearance of the nuts. The nuts should be thoroughly washed before being placed in the trays to dry and cure. The washing can best be done as the nuts are taken from the picking sacks and before the dirt adhering to the shell and the stain from the green hull dries. The cylinder washer will be found to be the best for washing the nuts. The time it takes to wash the nuts will depend on the condition of them, say from 10 to 20 minutes; use plenty of water.

Drying.—After the nuts are thoroughly cleaned they should be placed on trays in the sun, if not too warm, until thoroughly cured. The length of time will depend on the condition of the nuts and the weather. From 4 to 8 days will usually be sufficient. When the nuts are well cured the meats will be quite brittle; by this test you can tell when the nuts are properly cured. Care should be taken in drying soft-shell nuts. Too much sunshine will cause the nut to open; also the heat of the sun if very warm will start the oil in the meats, thereby causing the nut to become rancid. During foggy weather the nuts in the trays should be covered during the nighttime. This can easily be done by stacking the trays one upon the other and covering the top tray with burlap or any other material.

Blending plants.—While the blending plants are expected, so far as the appearance is concerned, to greatly improve our grade of walnuts, they will in nowise change the work of the grower in preparing the nuts for market, except sacking and delivering the crop to the walnut houses. It is especially recom-

mended that the growers, in delivering their walnuts to the association, use the ordinary grain or barley sacks, that the sacks be filled uniformly and sewed, and that the name of the grower be stenciled on opposite sides of each sack to prevent loss of identity of the nuts before being placed in the blending plant; and also to insure the return of the delivering sacks to the owner.

Twine.—The association will issue to stockholders, at cost, from the Rivera Walnut House on specific dates skeln twine for the use of stockholders for sewing the grain or delivering sacks.

All walnuts will be weighed when received from the grower and receipt for net weight given. Payment will be made in accordance with the by-laws of the association as soon as accounts can be made up after shipments of walnuts begin.

After receipt of the nuts at the processing plant they are conveyed to the first of a series of power-operated machines, where they are screened from any foreign substances gathered with the crop. After screening they are passed through the bleacher and then through the grader, though sometimes grading precedes bleaching. The nuts are next taken to assorters on an endless belt and carried to especially constructed aerating bins from which they are sacked and shipped.

GRADING.

From the screening machine the nuts pass into and lengthwise through a cylinder about 20 inches in diameter and 5 feet long, made of standard-size wire screen. This cylinder, called a grader, is set on an incline of about 15° and when rotated slowly allows the smaller nuts to pass through the mesh while the larger ones pass out at the lower end, separating the nuts, though not very accurately, into two grades called firsts and seconds.

To the writer there appears to be a weakness in the present method of marketing the crop. The product of the average orchard ought to have its firsts again separated into two grades if the crop is to obtain the returns to which it is entitled in comparison with other orchard crops. The average difference in price between firsts and seconds is about 20 per cent, somewhat less when prices are high and rather more when prices are low. Ordinarily there is as much difference between the sizes of the nuts marketed as firsts as between firsts and seconds, with the proportion reversed. The usual proportion between firsts and seconds is 9 to 1. On this basis, regrading of the firsts would put 9 per cent of the crop in a grade above the present first grade. This part of the crop on the present price scale would bring to the producer a net profit of nearly 2 per cent above what is now received, since there would be no additional cost in making the new grade. Should the walnut crop of the future be grown in large part upon grafted trees the above sizes and prices may not hold, since the fruit from grafted trees is much more uniform than from seedlings. Data of Franquette, Wiltz, and Concord nuts grown,

respectively, in the Vrooman, Wiltz, and Hutchinson orchards of grafted trees show less than 5 per cent of seconds in the average crop and practically no variation in the size of the nuts rated as firsts. Should like results prevail in future orcharding, and leading authorities in all walnut districts are freely of that opinion, there may be little need to increase the number of grades in future except with reference to varieties. The trade requirements of the future will demand that grades be distinguished in other respects than by size alone. In addition to grading for size and its accompanying cracking percentage as at present, the interests of the industry make it evident that steps must soon be taken to insure grading on a more comprehensive basis. The nut trade suffers materially from insufficient discrimination in such points as the following: Form of nut; bleaching, sealing, uniformity in type, smoothness, regularity, color, and thickness of shell; cracking percentage; darkness, veining, and astringency of pellicle; lean or fat kernels; toughness, tenderness, crispness, flavor, and quality of flesh.

Were walnuts graded as closely as oranges, lemons, apples, and pears there would be at least one more grade, and probably two, which would bring the grower of extra-large or fancy nuts a corresponding advance in revenue, with added incentive toward raising the grade and quality of the output.

BLEACHING.

From the grading machine the nuts pass to the bleacher, a cylindrical piece of machinery similar in size to the grader but made of straight wire rods running lengthwise and held in position by encircling cross wires. After being sprayed with electrolyzed brine in passing through this machine, which, like the grader, is supported on an incline, the first-grade nuts are carried to a drying bin to remain for a few days, where air currents may circulate freely among them. Meantime the seconds separated by the grader are placed in sacks to await their course through the bleacher when the firsts have passed out. As the firsts and seconds leave the bleacher on endless belts for the finishing, aerating, or drying bins they are handpicked or assorted. The sorts, called culls or shells, are placed in separate bins and sold to confectioners or concerns that engage in the preparation of shelled meats for market.

Electrolytic bleaching is far superior to the chlorid of lime bath or sulphur fumes. Being simple in preparation, clean, and effective, it is less injurious to the nuts and more wholesome for the consumer, as little, if any, material gets into the nuts, and then only into those that are unsealed. The solution used is made by dissolving 5 pounds best-grade dairy salt in 100 gallons of water. This solution is placed in a battery jar and an electric current of 95 to

110 volts is applied. The variation in the strength of the current depends upon the purity of the salt. The cell containing the liquid is kept at a temperature of 90° to 95° F. It is applied to the nuts as a spray with a pressure of about 80 pounds.

As soon as the bleached nuts are dry they are sacked in the same manner as the wheat crop of the Pacific coast. In some instances, for convenience in identification while being handled, the sacks carrying the firsts have stamped upon them lengthwise a distinct colored band or broad stripe.

A perceptible opposition to bleaching is manifest on the part of those consumers familiar with both the bleached and the unbleached product. Undoubtedly some of this unfavorable criticism in the past has been deserved, since it is well known that the old process of dipping in chlorid of lime permitted more or less of the solution to enter nuts not well sealed, rendering them disagreeable to the taste. This objection is avoided by the bleaching process already described, known as the salt bath, in which the solution rarely enters the shell, and if it does, nothing more than a mild salty taste is detected. Another objection to bleaching, which further investigation may overcome, is that it prevents the proper curing of the kernel through the destruction of the enzymes or other agents that develop in the unbleached nut.

While the bacteriologist is settling this question perhaps we may ascertain how to harvest, cure, and market the crop without the necessity of bleaching. At present a limited quantity of unbleached nuts are so marketed and, so far as known, bring prices equally high. The public will soon learn to accept the natural-colored nut, provided it is clean, unstained, and sold at the same price. The problem involves change in harvesting practices, and doubt arises as to the possibility of producing as uniformly clean and bright an output as is now offered by electrolytic bleaching without materially increasing the cost of production. In the face of what promises to be a growing sentiment against bleaching on the part of consumers who require a high-grade or fancy nut, the grower is likely to order his product to meet the consumer's demand.

STORING.

In the main, the keeping qualities of walnuts are excellent, but in order to insure the best results in storage they should be kept in a cool dry room constructed to exclude insects; otherwise wormy nuts will result from prolonged storage. Exposed to damp, nuts soon mold or decay, and even when dry the nuts will become rancid if kept too long. Dr. Thomas A. Knight, writing in 1811, said:

I have subsequently found that both chestnuts and walnuts may be preserved through the whole winter nearly in the state they came from the trees by cover-

ing them with earth (as potatoes are usually covered in the gardens of cottagers) and mingling a sufficient quantity of moderately dry mold with the nuts to occupy the space between them.¹

Such a practice might not be amiss for the orchardist keeping his own crop, but would be impracticable when the market demands a clean, bright, or bleached product. To meet this demand there appears to be only one course to follow, and that is to subject the crop to cold storage after being fully cured. A temperature such as is maintained for the storage of apples ought to be suitable for walnuts, though no reports of experiments upon this point have been made.

With walnuts that are to be stored for an extended period care must be exercised in the selection of thoroughly sealed nuts unless they are placed in air-tight chambers and kept cold. In ordinary storage chambers weakly sealed nuts are subject to serious damage by worms and weevils. Experiments now being made in the storage of pecans by C. A. Reed, of the Department of Agriculture, promise excellent results. Kernels cracked in 1911 were placed in vacuum-sealed glass jars, and on being opened in March, 1912 were found as crisp and fresh as when cracked. During this period the jars were stored in an office room at ordinary temperature. While storing walnuts commercially is somewhat different from this treatment of pecans in that the larger number of stored nuts will be unshelled, there appears to be no reason why the method should not give as good results with walnuts as with pecans.

WALNUT GROWING AS A BUSINESS.

PRODUCTION AND CONSUMPTION.

During the years of the past decade the quantity of walnuts marketed in the United States has been approximately as follows: ²

TABLE III.—*Persian walnuts marketed in the United States, 1902–1911.*

Year.	Domestic unshelled.	Imported.		Price for the home product. ³	Year.	Domestic unshelled.	Imported.		Price for the home product. ³
		Unshelled.	Shelled.				Unshelled.	Shelled.	
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Cents.</i>		<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Cents.</i>
1902.	13,800,000	10,394,048	2,594,288	9½	1907.	15,096,887	23,036,646	7,199,988	11
1903.	17,400,000	8,936,439	3,035,970	10	1908.	14,674,543	21,427,853	7,098,958	15
1904.	12,628,248	19,454,012	3,579,941	12½	1909.	20,286,769	17,432,885	8,781,909	12½
1905.	15,175,994	16,312,139	4,178,010	11	1910.	18,685,686	23,260,974	10,960,988	11½
1906.	12,776,136	15,029,724	4,948,175	13	1911.	19,388,776	21,146,116	11,244,055	15

¹ Transactions of the Horticultural Society of London, ser. 1, vol. 1, 1820, p. 247.

² Reports for the years 1902 and 1903 by the Southern California Walnut Growers' Association. The data for 1904 to 1911, inclusive, are taken from compilations made by F. A. Hazzard from the record of shipments made from points in southern California.

³ Net at the association's headquarters, less approximately 7½ per cent commissions.

According to the French ratio the shelled product is equivalent to slightly more than 40 per cent of the whole nut. The estimate of the total American consumption here given is based on this ratio for the imported product. It thus appears that the people of the United States during 1910 consumed approximately 35,000 tons of walnuts, more than 25,000 tons of which were imported. About five-sevenths of the importations came from France, while the larger part of the other two-sevenths came (in the order of the quantities imported) from Italy, Turkey in Asia, Austria-Hungary, the United Kingdom, and the Chinese Empire. Practically all of the home-grown commercial crop was produced in California, though Oregon sold a few carloads. A few thousand pounds were marketed from small orchards and individual garden, lawn, or roadside trees in Washington, New York, Pennsylvania, Maryland, New Jersey, and Delaware, while scattered trees in Michigan, Ohio, Virginia, West Virginia, Texas, and Georgia yielded a few hundred pounds for home use.

A great opportunity evidently exists for extending the area of production of the home crop. The present activity to secure hardier disease-resistant varieties of high quality and to improve the methods of propagation is evidence of the effort to take advantage of this opportunity. The interest of the public also suggests extended trial of the more promising hardy varieties over a wide range of such territory as appears at all suited to the successful cultivation of this tree.

YIELD.

There are authentic records of individual trees in Europe yielding as much as 2,000 pounds, while the largest yield recorded for an American tree is 712 pounds. This tree, known as the Payne tree, located at Campbell, Cal., is of magnificent proportions. It originated by the planting of a California black walnut in 1871. In 1896 the tree was top-worked with wood of the Santa Rosa Persian walnut. Though originally planted in a row with others, it grew so rapidly from the start that it soon overshadowed the others and has practically become an isolated tree, except for a white walnut, or butternut, some 60 or more feet away. Growing upon a deep fertile soil and fed by the wash of the barnyard, the crop of this tree is not a fair criterion by which to approximate the yield of a commercial orchard, though it has often served that purpose for the promoter of walnut orchards sold on the installment plan. In favorable seasons, with orchards growing upon deep rich soils well supplied with moisture, it is not unusual to harvest from an acre of seedling trees, 20 years of age, a ton or more of marketable nuts, but a conservative basis for investment is 1,000 to 1,200 pounds. The following statement from the books of a successful grower in the Rivera section of California

exhibits the results of an average orchard well managed. He had trees covering 8 acres 27 years old, 15 acres 16 years old, 12 acres 12 years old, and 7 acres 10 years old, which produced during 1910 nuts to the gross value of \$5,200, or an average of \$123.85 per acre. His approximate yield per acre was 825 pounds for 16-year-old trees. Statements of a yearly product considerably higher than these figures are frequently published, but careful inquiry among scores of successful growers in Oregon and California does not confirm them for average yields, one year with another, under varying conditions of soil and climate. It must be remembered, however, that statistics of yield from commercial orchards are taken at present almost exclusively from orchards of seedling trees, which are unquestionably less prolific than grafted trees of selected parentage. Though no authentic records are available, it is asserted that grafted trees of productive varieties, besides coming into bearing earlier, yield 20 per cent more nuts than average seedling trees. This estimate appears conservative when we consider that grafted trees may also be immune to blight. Further, the product of grafted trees brings a higher price upon the market. In the prices quoted for the output of the Southern California Walnut Growers' Association for 1910 nuts from grafted trees were favored by a 16½ per cent advance over the general seedling crop. These two items are of weight when the factors in profitable orcharding are under consideration.

TABLE IV.—*Statement showing number of farms reporting Persian walnuts, trees of bearing and nonbearing age, quantity produced, and value, census of 1910.*¹

State.*	Number of trees Apr. 15, 1910.				Products of 1909.	
	Bearing age.		Nonbearing age.		Quantity.	Value.
	Farms reporting.	Trees.	Farms reporting.	Trees.		
					<i>Pounds.</i>	
Alabama*	983	3,022	1,164	4,180	43,673	\$3,557
Arizona*	23	103	62	324	1,000	161
Arkansas*	182	1,284	182	1,260	15,436	1,384
California	7,357	853,237	6,554	546,804	21,432,266	2,247,193
Colorado.	6	39	7	80	25	3
Delaware.	6	15	7	15	222	44
Florida*	301	786	327	1,489	28,575	2,018
Georgia*	1,020	3,433	984	6,996	56,585	4,161
Idaho.	52	407	74	1,013	633	79
Illinois	87	772	12	1,045	3,497	331
Iowa.	1	200				
Kentucky*	106	1,227	46	1,193	35,825	1,499
Louisiana*	411	1,228	398	3,390	15,173	1,446
Maryland	754	2,068	444	1,758	6,916	745
Minnesota.	1	1	2	7	50	5

¹ The census tabulation shows no production of Persian walnuts in Connecticut, District of Columbia, Indiana, Kansas, Maine, Massachusetts, Michigan, Montana, Nebraska, New Hampshire, North Dakota, South Dakota, Vermont, and Wisconsin; but herbarium specimens and correspondence show that nuts of fair quality are grown in favorable sections of Connecticut, Michigan, and the District of Columbia.

* Observations and correspondence indicate that the enumerators in States marked with an asterisk (*) failed to distinguish between the product of the American black, the Japanese, and the Persian walnut. Students of horticultural conditions in these States, men of high scientific, professional, and business standing, assert that it is not possible to obtain such figures except by indiscriminate use of the term walnut.

TABLE IV.—Statement showing number of farms reporting Persian walnuts, trees of bearing and nonbearing age, quantity produced, etc.—Continued.

State.	Number of trees Apr. 15, 1910.				Products of 1909.	
	Bearing age.		Non bearing age.		Quantity.	Value.
	Farms reporting.	Trees.	Farms reporting.	Trees.		
					<i>Pounds.</i>	
Mississippi *	893	2,705	1,239	5,513	66,492	\$6,949
Missouri *	86	1,214	48	909	5,791	618
Nevada.....	8	39	11	148	200	20
New Jersey.....	170	429	138	1,360	2,798	302
New Mexico.....	15	250	123	1,641	715	91
New York.....	81	456	28	139	9,346	858
North Carolina *	563	2,125	509	1,731	73,303	3,696
Ohio.....	71	599	30	220	2,461	154
Oklahoma *	252	6,889	198	5,962	6,700	439
Oregon.....	1,134	9,526	4,300	177,004	70,060	8,288
Pennsylvania.....	53	198	68	142	4,523	516
Rhode Island.....	1	4	1	1		
South Carolina *	473	1,373	526	1,834	28,160	2,583
Tennessee *	96	437	49	137	4,157	296
Texas *	626	9,685	704	13,015	40,658	3,703
Utah.....	53	292	42	484	5,985	533
Virginia *	371	3,540	194	1,642	22,512	1,231
Washington.....	509	3,651	1,461	23,406	16,450	2,241
West Virginia *	121	3,035	59	1,481	17,337	2,153
Wyoming.....	1	1				

FOOD VALUE.

According to Prof. M. E. Jaffa, of the University of California, who has made extended analyses of the composition of nuts and other foods, walnuts, inclusive of the shells, are estimated to comprise a waste of about 58.8 per cent of the uncracked nuts as usually found upon the market. They have a value as represented by the heat units (calories) they furnish, pound for pound, comparable with other food products, as shown in Table V.¹

TABLE V.—Average fuel value of walnuts as compared to other food products.

Food product.	Average price per pound, 1910.	Refuse.	Fuel value of edible portion.	
			Calories per pound.	Calories for 1 cent.
		<i>Per cent.</i>		
Round steak.....	\$0.15		950	63
Wheat flour.....	.04		1,650	412
White bread.....	.05		1,215	243
Dried beans.....	.045		1,605	356
Raisins.....	.10	10	1,605	145
Walnuts.....	.25	58.8	3,075	51

¹ Yearbook, U. S. Dept. of Agriculture, for 1906, p. 209.

Considering the comparative value of walnuts and other food products, it is evident that the walnut can not be rated according to present market prices as an article of ordinary diet. Before the Persian walnut can become an article of daily consumption the crop must be produced in much larger quantities, necessitating extensive additional acreage. Relatively little high-class land suitable for the Persian walnut is available in southern California, except at very high cost. This region offers several thousand acres suitable for the production of this crop, provided care is used in the selection of site and varieties, though the fact is that much of this acreage will probably be planted to crops yielding earlier and more profitable returns. It will be necessary to enter other districts if the crop is to keep pace with the increased consumption, and preliminary tests warrant the statement that the crop can be successfully and profitably grown in other sections.

In connection with the topic of food value, it may be well to call attention to one or two features of the American-grown nut that merit attention, especially by those engaged in its improvement. The connoisseur of nuts is persistent in his assertion that the kernels of the French varieties when grown in the United States are much more starchy than when grown in France. He also asserts that many of our best American-grown nuts are more or less bitter and astringent.

These criticisms are not made in a spirit of disparagement but of helpful suggestion. It is assumed that if our nuciculturists have accepted ideals placed before them effort will be made to embody these ideals in American seedlings, insuring sooner or later a nut vastly improved in those properties that make a product of the highest quality.

At present the American public does not discriminate between the different varieties, types, or qualities of walnuts. When the home product shall equal or excel home consumption more discrimination will be shown. Already American growers are awake to the need of arousing the public to an appreciation of the fact that the first-grade home product is not to be classed with the foreign varieties generally used for replacement purposes.

It is opportune to have this matter of American quality brought to the attention just as we are beginning a notable advance in the improvement and culture of this nut, and to the criticism and demand of the connoisseur we shall be indebted for stimulation in the development of new and better varieties.

INVESTMENT AND OPERATION.

Though seasonal variations bring more or less change in the tillage operations of a walnut orchard, the following figures recording the

experience of growers throughout California, Oregon, and Washington may be considered a conservative estimate of the investment and expenses necessary to produce and market an average crop of walnuts. The average crop one year with another from trees 15 to 25 years of age is 1,000 to 1,200 pounds per acre.

In the States named first-class land suitable for walnut growing cleared and ready for planting costs \$150 to \$1,000 per acre according to location. In outlying sections, especially in northern California, Oregon, and Washington, land may be bought for \$100 per acre. In sections where the walnut finds a congenial home higher prices prevail. Grafted trees cost \$1 to \$1.50 each; preparation of the soil and planting the trees, \$4 to \$6 per acre; pruning, 75 cents annually per acre as an average for the first 10 years; two or three times that amount for the next 10-year period, and slightly more afterwards; tillage, \$12 to \$20 per year if no intercrops are grown; irrigation, \$2 to \$6, according to character of soil, season, age, and bearing of the trees; fertilizers and cover crops (for nitrogen and humus) \$2.50 to \$5; superphosphate, \$8 to \$10; harvesting, \$20 to \$30 per ton; charges for processing, \$10 per ton; commission on sales, 7½ per cent. The average price of the product during the past 10 years has been 12½ cents per pound f. o. b. at point of shipment on the Pacific coast.

NOTE.—Since the second paragraph on page 20 was written, the severe winter of 1911-12 wrought such damage to all Persian walnut trees on their own roots that it is necessary to change the tenor of the statements therein. Throughout eastern Pennsylvania and in the District of Columbia many old trees were killed outright or so severely injured that they will die within a year or two. In those instances, however, where the writer has made a personal examination the trees were found to be growing under the unfavorable conditions usually prevailing in the walled-up back yards of cities. A few trees growing under the more favorable environments surrounding country homes in this same territory have been reported as suffering severe injury from the low temperatures, -20° to -33° F., of January, 1912.

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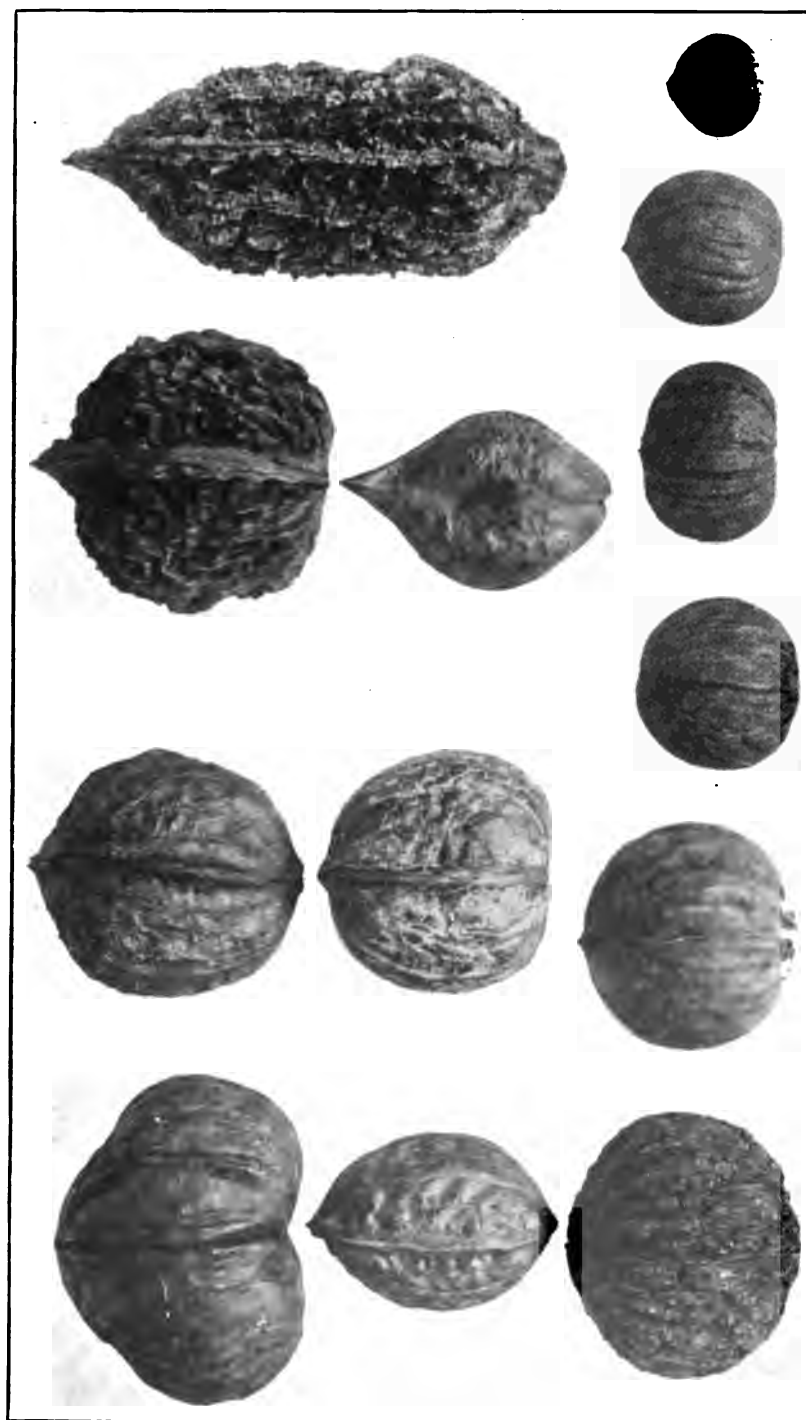
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PLATES.

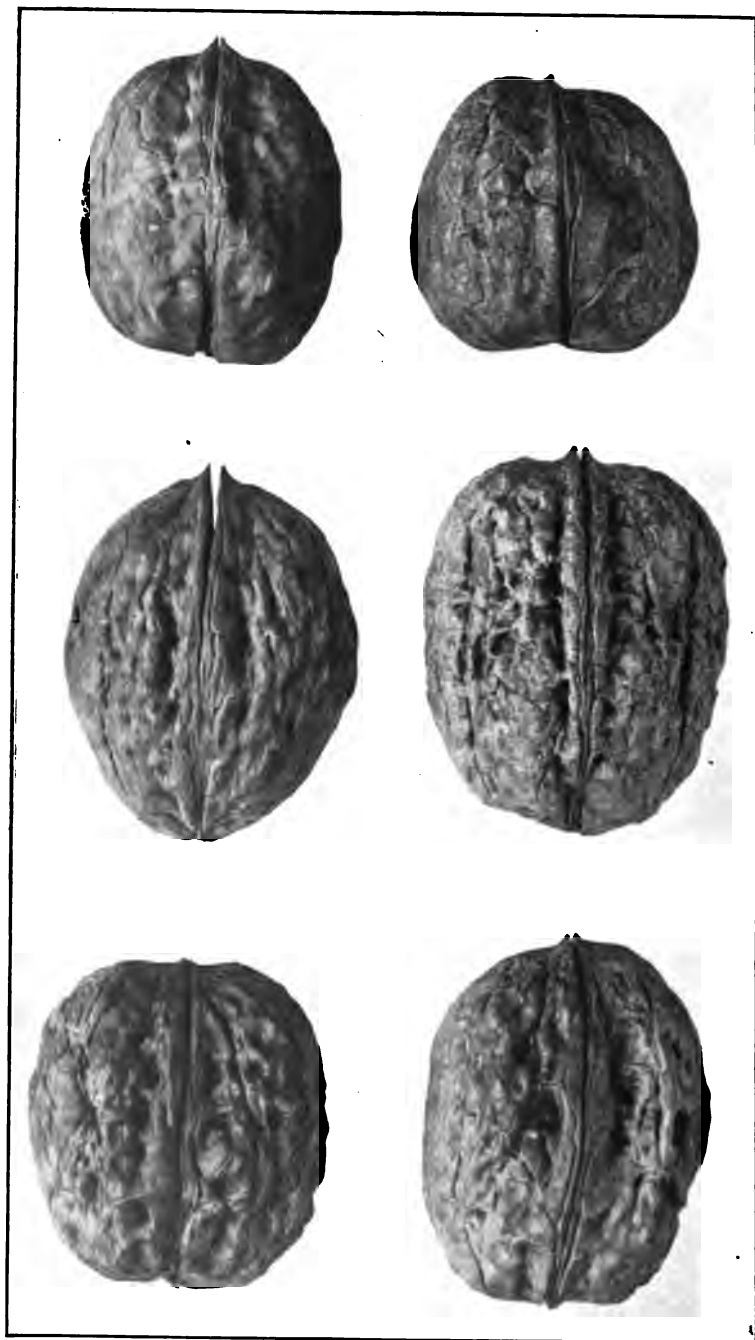
DESCRIPTION OF PLATES.¹

- PLATE I. (*Frontispiece*.) A well-kept Persian walnut orchard in California, illustrating the thorough tillage that may be readily maintained among low-headed trees.
- PLATE II. Varieties of walnuts—I. The principal species and hybrids now attracting attention in this country. Upper row, from left to right: Royal (*Juglans nigra* × *Juglans californica*), Paradox (*Juglans regia* × *Juglans californica*), Ignotum (*Juglans regia* × *Juglans cinerea*), Butternut, or white walnut (*Juglans cinerea*). Middle row: Siebolds Japan walnut (*Juglans sieboldiana*), Chinese walnut (*Juglans regia sinensis*). Heart-shaped Japan walnut (*Juglans cordiformis*). Lower row: American black walnut (*Juglans nigra*); (*Juglans californica*), northern form, California black walnut, southern form; rock or Texas walnut (*Juglans rupestris*), flat form; rock or Texas walnut (*Juglans rupestris*), long form; rock or Texas walnut (*Juglans rupestris minor*), Arizona form.
- PLATE III. Varieties of walnuts—II. Top row, left to right: Bljou, Klondike, Honeydew. Bottom row: Hall, Payou, Meylan.
- PLATE IV. Varieties of walnuts—III. Upper row, left to right: Grenoble, Santa Rosa, Persian, Sorrento. Lower row: Santa Barbara, Santa Barbara (Williams form), Santa Barbara (More form), Hardshell.
- PLATE V. Varieties of walnuts—IV. Upper row, left to right: Mayette, Concord, Ward, Chelan. Lower row: Neff, Franquette, Parisienne, Nebo.
- PLATE VI. Varieties of walnuts—V. Upper row, left to right: Two French seedlings (varieties on the same tree), Fertile, Chaberte, Cumberland. Lower row: Placencia, Mayquette, Kaghazi, Chase.
- PLATE VII. Varieties of walnuts—VI. Upper row, left to right: Ford, Eureka, Rush, Prince. Lower row: Holden, Treyve, Payne, Prolific.
- PLATE VIII. Varieties of walnuts—VII. Upper row, left to right: Alpine, Journey, Mount, Cluster. Lower row: Vourey, Hubbard, Serotina, Late Fertile, Cutleaf.
- PLATE IX. Varieties of walnuts—VIII. Upper row, left to right: Hales, Keesling, Milbank, Lane. Lower row: Hays, Lalande, Derby, Lea, Sinclair.
- PLATE X. Varieties of walnuts—IX. Upper row, left to right: Chase 2, Chase 1, Kaghazi, Mayquette. Lower row: Pomeroy, Pomeroy seedling, Chaberte, Fertile, Dean.
- PLATE XI. Varieties of walnuts—X. Upper row, left to right: Franmay, Prince, Wiltz, Glad. Lower row: Ellwood, Cumberland, Placencia, Persian (round).

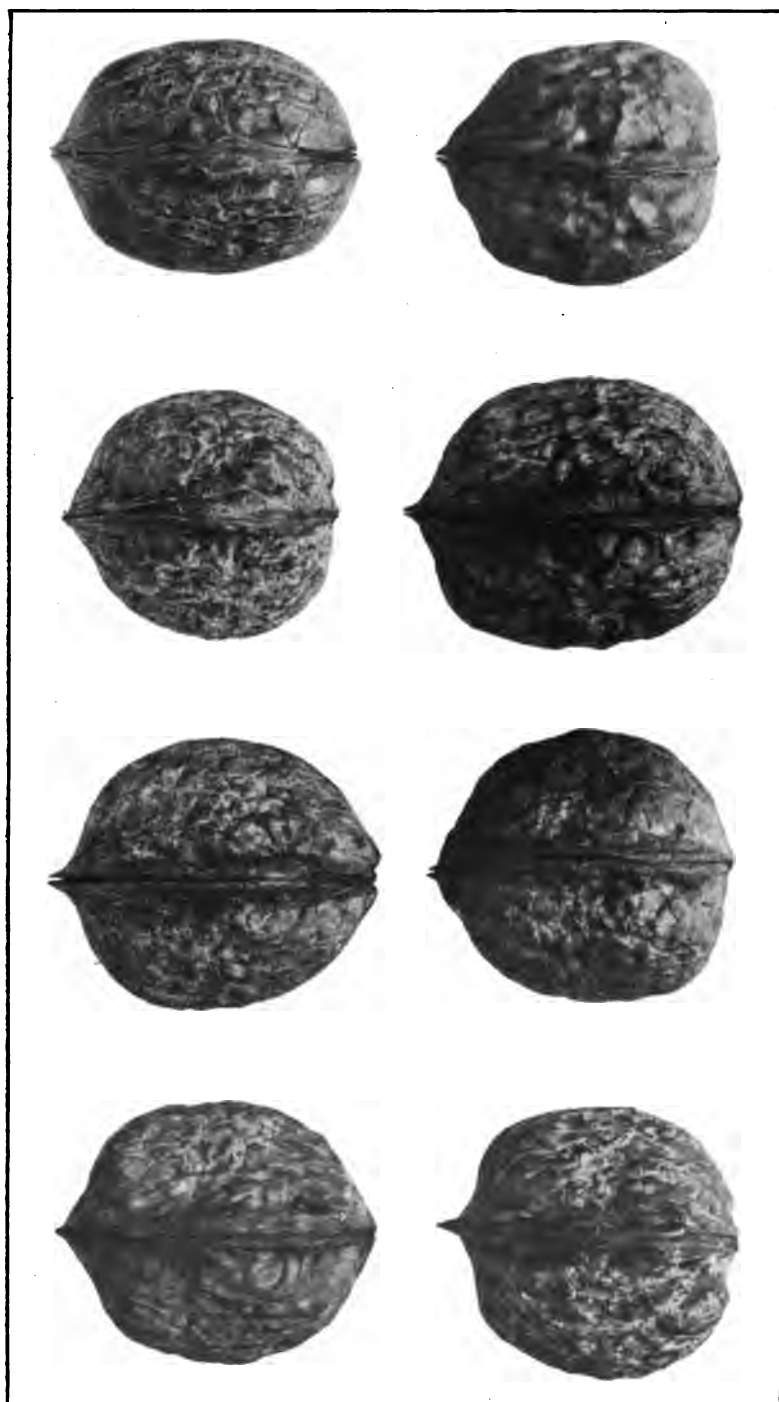
¹ The bottom row in each instance is the lengthwise row next the plate legend.



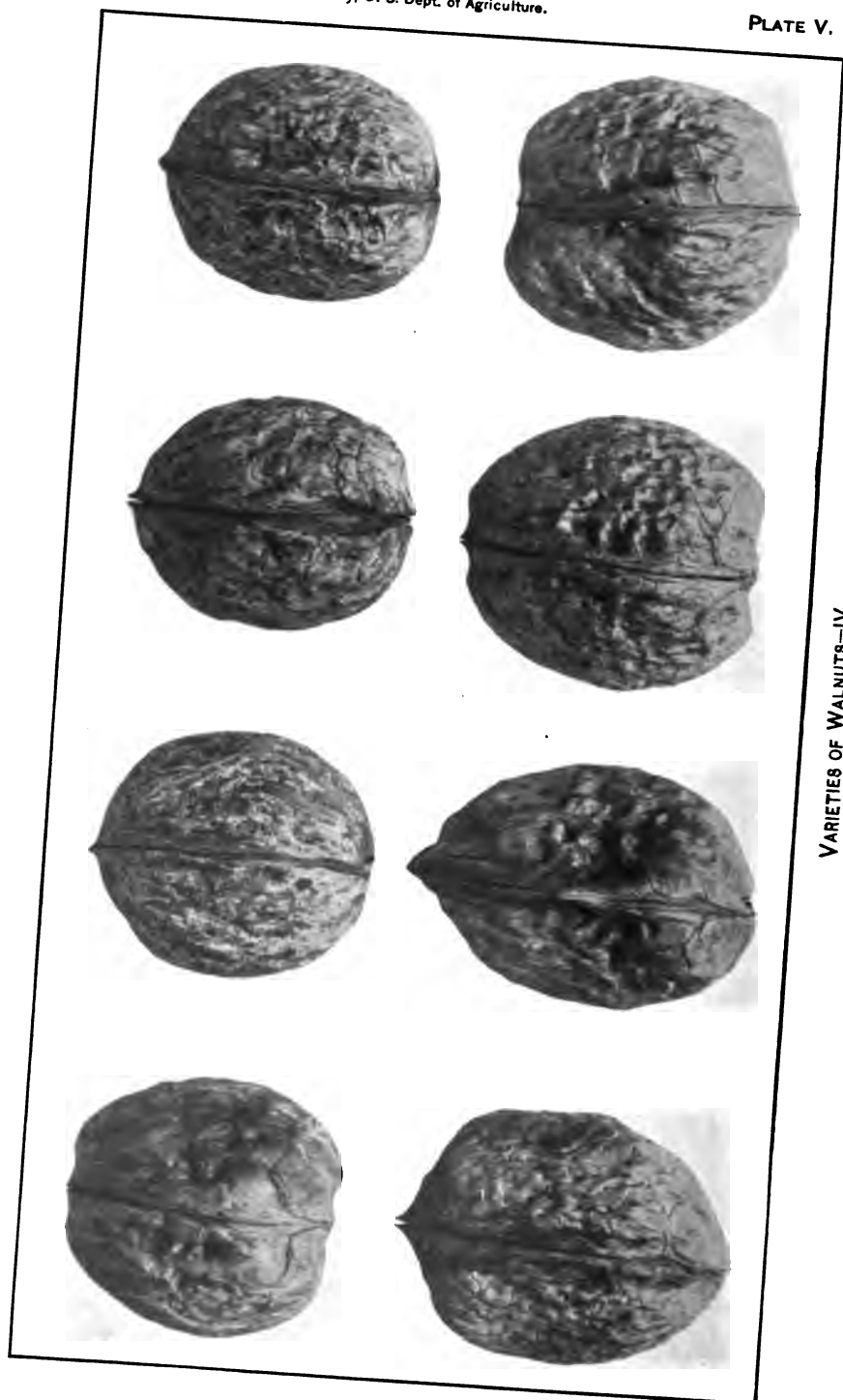
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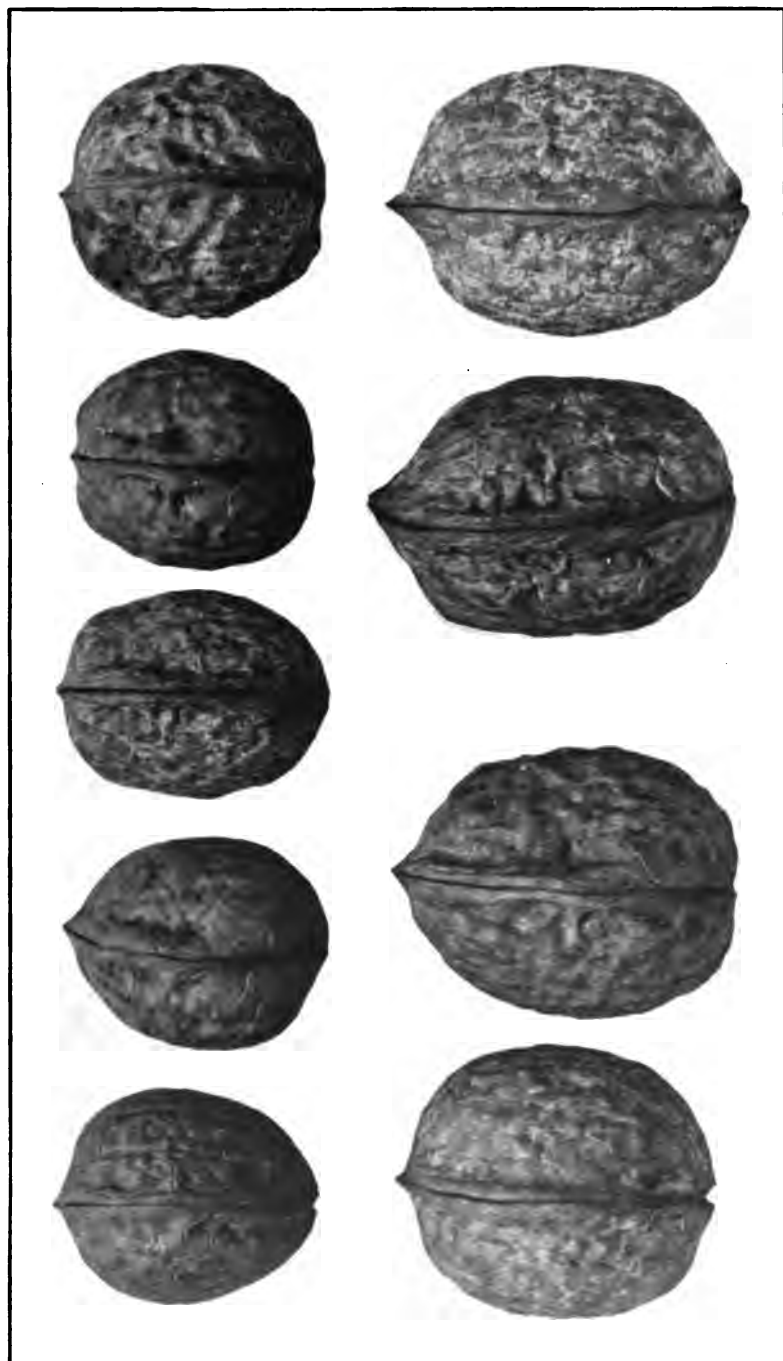
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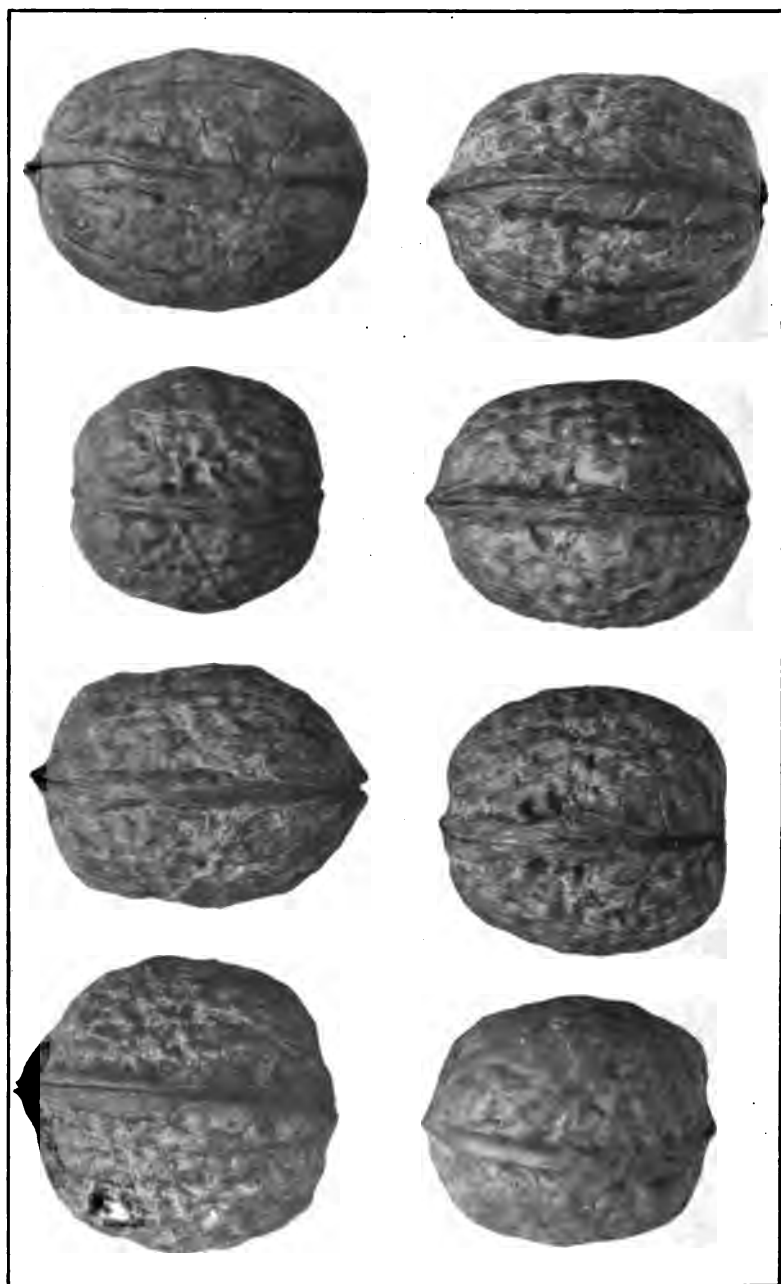
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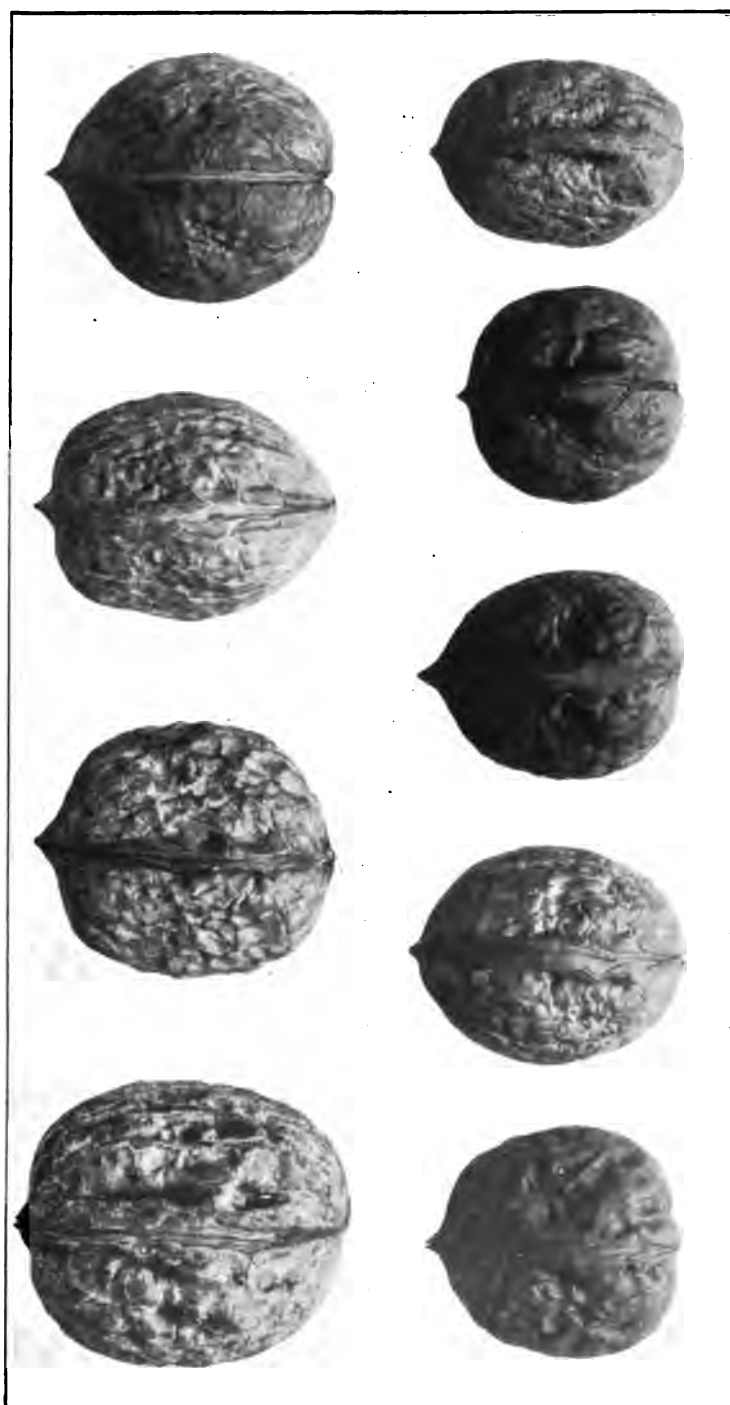
VARIETIES OF WALNUTS—IV.



VARIETIES OF WALNUTS—V.



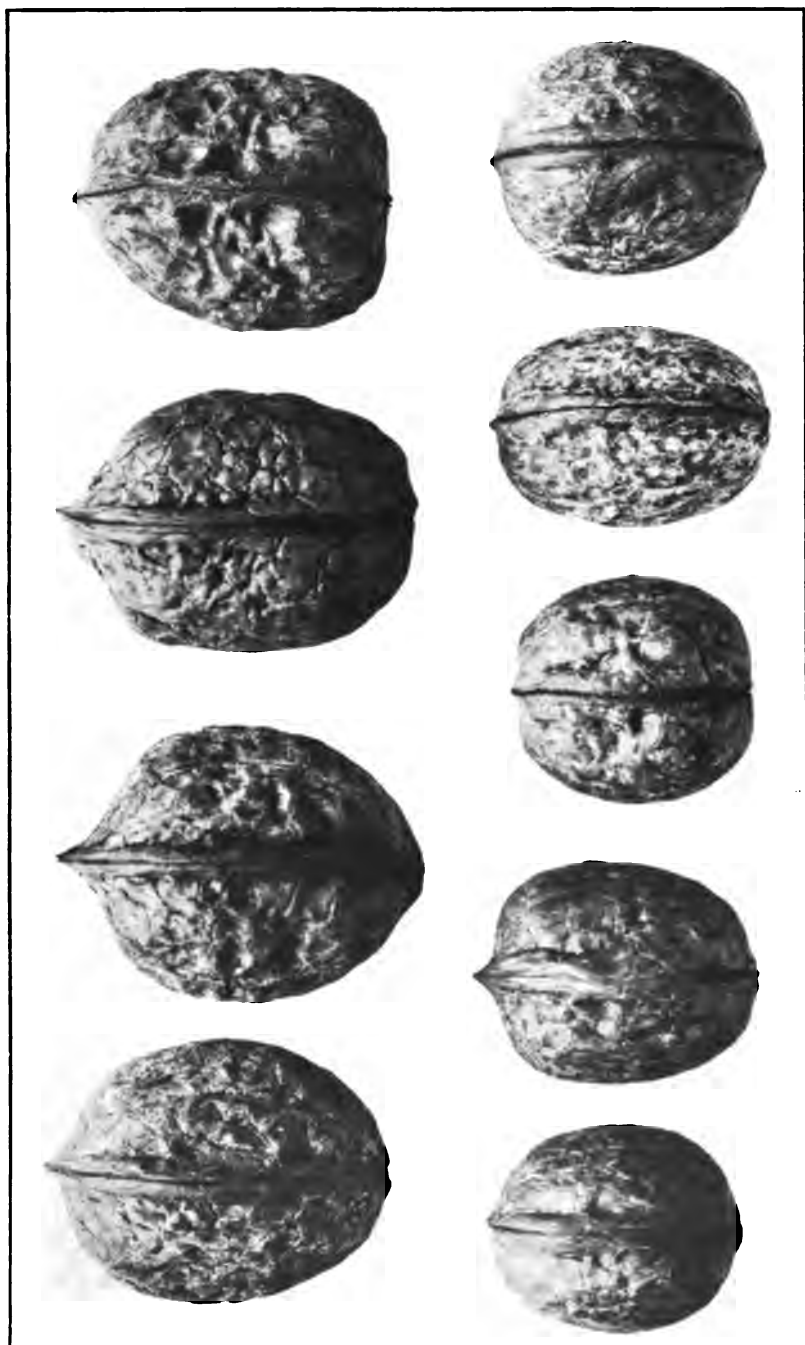
VARIETIES OF WALNUTS—VI.



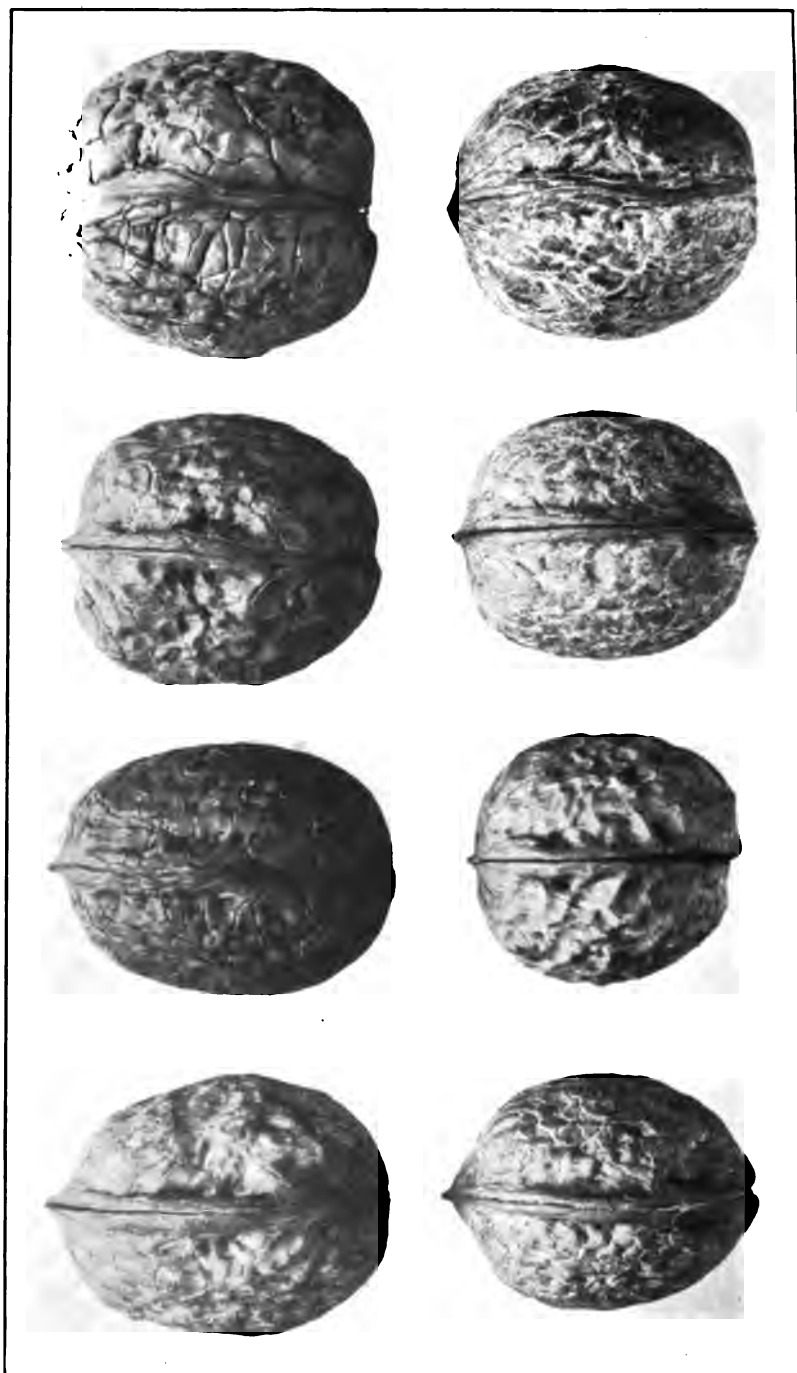
VARIETIES OF WALNUTS—VII.



VARIETIES OF WALNUTS--VIII.



VARIETIES OF WALNUTS—IX.



VARIETIES OF WALNUTS—X.

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B. T. GALLOWAY, *Chief of Bureau.*

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BY

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